

A REPORT ON THE ECHINI OF THE WARMER EASTERN PACIFIC, BASED ON THE COLLECTIONS OF THE

VELERO III

(PLATES 35-71, TEXT FIGURES 1-3)

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The great collections of Echini (28,835 specimens, including over 11,000 young *Dendrasters*) made by the *Velero III* under the direction of Captain Allan Hancock, during the years 1931-1941, have proved a field for research as varied and interesting as it is large and illuminating. It was just eighty years ago that Verrill published his first papers on the Echinoderms of Panama and the western coast of America and for four years he continued his studies of that fauna. In 1871 there appeared (Trans. Conn. Acad. vol. 1, pt. 2, art. 5, no. 8, pp. 593-595) his list of the Echini of the Gulf of California which included 22 species. Subsequent additions and emendations enabled A. Agassiz in 1904 to list 28 species from the Panamic region and 21 more from very deep water (300-2200 fms). In recent years additional species have now and then been added or corrections made, so that Grant and Hertlein (1938) include some 47 recent species in their list. Several, however, are from very deep water and are hardly to be counted in the present fauna of the warmer Eastern Pacific.

The area thus designated may be defined as extending from the coast of Oregon at Ocean Park (Lat. 44° 50' 45" N), southward along the American coast to San Juan Bay, Peru (Lat. 15° 20' S), and westward to include the islands, Socorro, Clarion, Cocos, and the Galapagos, down to depths of 80 fms or less, very rarely to 300-400 fms. In depths exceeding 100 fms, the water is no longer warm and the bottom fauna can not be properly included as belonging to the "warmer Eastern Pacific." The great gulf of California has an interesting fauna including 22 species of Echini. Only one of these, however, is restricted to the Gulf, 8 extend their range to the north and 19 to the south. Due to certain local restrictions, collecting along the coast of Mexico and Central America did not yield so large a number of Echini as did the Gulf, and even in the Bay of Panama only 18 species were taken. Colombia yielded but 11 species while Ecuador has 14 to her credit and only 6 were recorded from Peru. North of the international boundary (United States-Mexico) some 14 species have been taken by the *Velero*. The outlying islands have proved good collecting grounds, for while Cocos yielded only 11 species, Clarion had 10, Socorro 12, and the Galapagos no few than 23, of which 4 were not found elsewhere.

The five visits of the *Velero* to the Galapagos, occupying 245 stations, have undoubtedly served the purpose of making the Echinoderm fauna of that group sufficiently well known to warrant the belief that it is essentially American and has not received any considerable influx of Indo-Pacific forms. Several of the species are, so far as we now know, endemic and warrant a belief in the long-sustained isolation of the marine fauna. In view of this it is worth while to list here the Galapagos Echini with a few words as to their occurrence:

<i>Eucidaris Thouarsii</i>	generally Panamic and western Mexico
<i>Hesperocidaris panamensis</i>	Cocos Island, Galapagos Islands and Ecuador
<i>Centrocidaris Doederleini</i>	Cocos and Galapagos Islands
<i>Centrechinus mexicanus</i>	generally Panamic, Mexico and Galapagos Islands
<i>Centrostephanus coronatus</i>	generally Panamic, Gulf of California, southern California
<i>Lytechinus semituberculatus</i>	Galapagos Islands
<i>Toxopneustes roseus</i>	Panamic, Socorro Island
<i>Tripneustes depressus</i>	Panamic, Mexican Islands
<i>Caenocentrotus gibbosus</i>	Ecuador, Peru and Galapagos Islands
<i>Echinometra oblonga</i>	Indo-Pacific to Northern Galapagos Islands and Mexican Islands
<i>VanBrunti</i>	Panamic, Western Mexico
<i>Clypeaster elongatus</i>	Galapagos Islands
<i>europacificus</i>	Panamic, Western Mexico
<i>ochrus</i>	Panamic
<i>rotundus</i>	Panamic, Western Mexico
<i>Encope galapagensis</i>	Galapagos Islands
<i>Cassidulus pacificus</i>	Panamic, Mexican Islands
<i>Agassizia scrobiculata</i>	Panamic, Gulf of California
<i>Brissopsis pacifica</i>	Panamic, Western Mexico, southern California

<i>Idiobryssus coelus</i>	Galapagos Islands
<i>Meoma grandis</i>	Panamic, Western Mexico
<i>Gonimaretia laevis</i>	southern California and Gulf of California
<i>Lovenia cordiformis</i>	Panamic, Western Mexico, southern California

Aside from the light thrown on the distribution of the known Echini in the Eastern Pacific, the *Velero* has collected an abundance of material useful in delimiting the known species, and revealing the existence of 11 forms which appear to require names as they do not fit too well into the series of species now known. One of these is a Cidarid and one a Clypeaster, but others are Scutellids of the well-known genera *Dendraster* and *Encope*. Never before have such large numbers of specimens been available for comparative study, and it is not strange that new and perplexing forms occur which require designation. Quite likely more material from the coasts of southern Mexico, Costa Rica, Nicaragua, and Panama will indicate different and more correct grouping, but it is believed that the specific limits here suggested indicate a step forward in our knowledge of these multiform genera.

The naming and describing of new species, however, is only one product of the *Velero's* extraordinary collecting. Equally important is the accumulation of immature and very young individuals showing stages in the development of the adult which throw light on evolutionary processes. The most striking of these is exhibited in the growth changes of young *Spatangus*, a genus represented by but one species in the Eastern Pacific, widely separated from its congeners in Europe, Asia and Africa. The *Velero* first met with *Spatangus* in 1936 in the Gulf of California but later collections showed that the vicinity of the Channel Islands in depths of 35-225 fms is the real home of this interesting sea-urchin. Considerably more than two hundred specimens are in the collection and quite a number are young, including some very early stages of development, only about 3 mm long. In these very small individuals there is no indication of either petals or pores. When the individuals are 8 or 9 mm long the petals are indicated by more definite outlines and slight depressions, but there are no pores. After the length exceeds 10 mm, the petals can be distinguished more or less definitely and pores are visible at the apical end of the ambulacra. But the pores are single and the petals evidently are not sunken at all. There is thus a Palaeotropus stage of development shown which is usually passed through before the *Spatangus* is 12 mm long. In some

cases, however, the growth changes are retarded and one individual caused much perplexity as it is 20 mm long and still reveals only single pores in the petals and hence was regarded as a new species of *Palaeotropus*. But the discovery of intermediate stages, showing all steps from poreless plates to normal twin-pored petals has been convincing in the demonstration of this striking example of stages in development, so ably presented by Jackson (1899).

For the opportunity to study this extraordinary collection, the writer is greatly indebted to Chancellor R. B. von KleinSmid of The University of Southern California and to Captain Allan Hancock and Professor Irene McCulloch of the Allan Hancock Foundation. Lieutenant Commander Fred C. Ziesenhenné, who played a major part in the collecting, preserving and arranging of the material, deserves high praise for the quality of his work. For the pleasure of being his co-worker in the 1938 cruise of the *Velero III*, I am deeply indebted to Captain Hancock. That was one of life's great experiences and words are quite inadequate to express my appreciation. Finally I take pleasure in acknowledging the very great debt I owe to Mrs. Ora Willett for her patient assistance in the study of the collection and in the preparation of the manuscript—assistance for which these few words of appreciation are quite inadequate.

Order **CIDAROIDA**Family **Cidaridae****Eucidaris Thouarsii** (Valenciennes)

Plate 35, Fig. 1

Cidaris Thouarsii L. Agassiz and Desor, 1846, p. 326.*Cidaris (Eucidaris) Thouarsii* Döderlein, 1887, p. 20.*Eucidaris Thouarsii* Mortensen, 1928a, pp. 393-400, pl. 42, figs. 5-13.

There are, in the Hancock collections, more than 1,200 specimens from 175 stations. They range in size from 3.5 to 67 mm in diameter. The largest and finest specimens are from the Galapagos Islands, particularly Darwin Bay, Tower Island, and Cartago Bay, Albemarle Island. The character of the spines, both primary and secondary, shows extraordinary diversity. The secondaries range from relatively short, truncate spines to rather long ones tapering to a chisel-like tip. The primaries show even greater diversity ranging from short, stout spines with diameter .25-.30 of length to slender terete spines with greatest diameter less than a tenth of the length. There is great diversity also as to the extent to which the spines are covered with sponges, bryozoa or calcareous algae. Occasionally these foreign growths increase the diameter of the spine (at least at its base) to one-third of its length. In other individuals of the same size, from the same station, the spines may be entirely free from any foreign growth.

The greater part of the *Velero* collection of *Thouarsii* is from the Galapagos Islands and a notable proportion of these individuals are larger and stouter than the material from the mainland coast. The specimens from Colombia, Panama, Costa Rica, and Mexico are on the whole smaller and have more slender spines than those from the islands. Occasional, sometimes conspicuous, exceptions prevent the drawing of any clear line of distinction however. Mortensen's emphasis on the "nearly black" secondary spines in *galapagensis* is misplaced as most specimens from either mainland or islands have the secondaries a deep purplish brown, the shade apparently deepening with age. On the whole, it seems to me futile to try to maintain any well-defined form as a variety or subspecies *galapagensis*.

Mortensen (1928, p. 399) has called attention to certain peculiarities in a specimen from Clarion Island which, if constant, would warrant recognition as at least a variety of *Thouarsii*. Unfortunately the present collection contains only a very few specimens from Clarion Island. While the largest of these seems to resemble the one studied by Mortensen, the others are not distinguishable satisfactorily from specimens from the mainland coast. Further collecting at Clarion Island is greatly to be desired.

Distribution.—This is one of the most characteristic sea-urchins of the western coast of tropical and subtropical America. *E. Thouarsii* occurs also at the outlying islands (Clarion, Socorro, Cocos and the

Galapagos), but not at great depths. Mortensen reports it in 45 fms in the Gulf of Panama, while the *Velero* took specimens at depths of 62-76 fms off Angel de la Guardia Island in the Gulf of California. The most northerly point from which it is reported is near Consag Rock in the Gulf of California. It is noteworthy that it has not been taken along the western coast of Lower California. Its southern limit, on the continental coast, is La Plata Island, Ecuador. It is very common among the Galapagos Islands where the *Velero* collected specimens at no fewer than 70 stations.

Type.—Paris Museum?

Type locality.—"Californie (Neboux.) Galapagos."

Depth.—Shore to 76 fms.

Specimens examined.—1,201 specimens from 175 stations.

***Hesperocidaris panamensis* (A. Agassiz)**

Plate 35, Fig. 2

Dorocidaris panamensis A. Agassiz, 1898, p. 73; 1904, p. 20, pls. 1-4.

Hesperocidaris panamensis Mortensen, 1928, pp. 73-74; 1928a, Mon. Ech. p. 416.

The material hitherto known of this sea-urchin consists of a few specimens taken by the *Albatross* in 1891 and now distributed in the U.S. National Museum, the Museum of Comparative Zoology and the British Museum. The *Velero*, however, has secured no fewer than 84 specimens, ranging from 4 to 49 mm in diameter; the height of the test is about half as much or a little more; both the upper and lower surfaces are definitely flattened. The very young individuals are white orally but more or less light coral red above; the primary spines are whitish with a tinge of red (at least basally) and have one or two ill-defined dusky bands and orange-red or flesh-red collar. In one specimen from the Galapagos Islands (Station 183-34) in 50-70 fms, the primaries are white except for more or less of the tip which is to some extent dusky or reddish; the contrast between such primaries and the dull red secondaries is striking. With increasing size, however, the primaries become unicolor, gray or brownish, save for the collar, and rapidly increase in darkness until in adults, they are deep brown or brownish purple, except where more or less incrustated with bryozoa, or other symbiotic forms. As a rule incrustation is not extensive and the primaries are slightly flattened at the tip. In young specimens the collar tends to be conspicuously orange red, but with age the color deepens and in adults is dark red or even reddish purple of a very dark shade. The secondary spines are brownish red in small specimens but become dark, almost a deep blood red in adults. A full grown specimen is thus a very striking and rather handsome urchin. In some individuals the young primaries at the upper end of each series

are uniformly more or less coral red in rather noticeable contrast to the older spines; this is particularly striking if the spine is entirely free from bryozoa or other incrustations. On the whole the coloration and general appearance of *panamensis* is remarkably uniform and makes the species easy to recognize.

Distribution.—The most striking fact about the distribution of this Cidarid is that it has not yet been taken at Panama or anywhere else on the coast of North or Central America. The original specimens were from the vicinity of Cocos Island, and from 85-112 fms off Galera Point, Ecuador. The *Velero* material is all from Cocos Island and vicinity, where this handsome urchin is notably common in 30-50 fms, or from the Galapagos Islands where it was taken at eight stations in depths of 30-150 fms, chiefly in the vicinity of Albemarle Island. The station numbers are: 143-34, 147-34, 155-34, 171-34, 183-34, 190-34, 324-35, 325-35, 772-38, 773-38, 780-38 and 810-38.

Type.—M.C.Z. no. 327 (Cotype).

Type locality.—"Cocos Island and Galera Point, Ecuador."

Depth.—30-150 fms.

Specimens examined.—84 specimens from 12 stations.

***Hesperocidaris perplexa* (H. L. Clark)**

Plate 36, Fig. 3

Tretocidaris perplexa H. L. Clark, 1907, p. 205; pl. 6, figs. 1, 2; pl. 7, figs. 1-4.

Hesperocidaris perplexa Mortensen, 1928, p. 421.

Only five specimens of this near relative to *panamensis* were known hitherto, so that the large series of nearly 500 specimens in the *Velero* collections contribute all the information needed to verify the authenticity of the species and reveal such diversity as it shows. The specimens range from 5 mm in test diameter, with spines scarcely 5 mm long to large adults with the test 43 mm in diameter and 25 mm high, with primary spines 35-43 mm long. The flattening of the distal part of the large primary spines, on which Mortensen lays great stress, is not evident until the test is 30 mm or more in diameter and even then it is not conspicuous in most specimens. In the most extreme case at hand, the test is about 37 mm in diameter and the longest primaries are about the same; the tips of ten or a dozen of these, at or above ambitus, are 3 to 5 mm wide; the distal half of each of these widened spines is very rough with crowded, more or less sharp tubercles. In most specimens the primary spines are nearly cylindri-

cal even at tip or somewhat terete, and are seldom noticeably rough. Their color is grayish or dull brownish but is frequently altered by bryozoa, sponges or other foreign growths. The striking and very constant feature of the coloration in *perplexa* is the conspicuous broad, brown longitudinal stripe which occurs on *all* the spinelets. The test itself is more or less yellowish or greenish but this shade is well shown chiefly, if not only, in the ambulacral mid-zones. The color of the basal part of the primary spines is commonly pale brown, usually greenish or yellowish just above the collar. The collar itself may have a more or less similar tint or may be more green, or yellow; in many specimens the general color of the spine is more or less dark brown, with the primary color flesh red or yellow brown. There is a great deal of variety in the shades of color in *perplexa*, some individuals being notably dark while many specimens, especially when young are definitely light. But no matter what the shades may be one feature of the coloration is remarkably constant and that is the longitudinal dark stripe found on all the secondary, and smaller, spines.

Distribution.—Judging from the *Velero* collections, this *Cidarid* is particularly characteristic of the Gulf of California, having been taken at 16 stations, as far north as 29° 39'. Off the west coast of Lower California, there are no records, save one half grown specimen in poor condition supposed to be from Station 1119-40, south of San Benito Islands, and a very young individual also in poor condition labeled as from Station 1153-40, off Santa Catalina Island, California. It is probable that these two specimens have in some way become mislabeled.¹ South of Lower California, no specimens were taken save at Bahia Honda, Panama, (Stations 244-34, 863-38, and 948-39) in 30-50 fms, north of Gorgona Island, Colombia (Stations 854-38 and 855-38) in 10-60 fms, and off La Plata Island, Ecuador, (Stations 212-34, 213-34) in 7-55 fms. The entire absence of *perplexa* from the Galapagos area is worthy of note and even more remarkable is its absence from the vicinity of Cocos Island, where *panamensis* is common.

Type.—M.C.Z. no. 188.

Type locality.—Gulf of California.

Depth.—36-39 fms.

Specimens examined.—487 from 25 stations.

¹ There are evidences in the studies of other groups that unexpected distributional records are not uncommon. The work of the *Velero III* must be considered as the preliminary exploration of a coast involving many miles with little information concerning the fauna of the intervening areas. Ed.

***Hesperocidaris asteriscus*²**, new species

Plate 36, Fig. 4; Plate 37, Figs. 5-6

Test somewhat flattened; vertical diameter about .60 of horizontal; coronal plates 6; areolae large, occupying most of plate surface; median interambulacral area narrow and fully covered with tubercles, smallest next to vertical suture which is quite indistinct; ambulacra about one-third of interambulacra in width; poriferous zones rather wide and hardly at all sunken; median ambulacral area narrow with a single row of relatively large tubercles on each margin and between these an irregular double series of much smaller tubercles which become more and more scattered and disappear entirely before the ocular plate is reached; pores rather large, horizontal or slightly oblique, nearly circular. Abactinal system about .50 h. d., rounded pentagonal, clearly defined, the anal area somewhat elevated; each of the component plates and the anal area covered (save on the margins) with flat spinelets, the larger ones on the anal system with truncate or rounded tips, the others quite acute; the genital plates carry 30-35 spine-bearing tubercles, the ocular plates about 20; genital plates distinctly longer than wide and much wider at the inner end than at the slightly convex outer end; ocular plates triangular, twice as wide as long, the margins slightly convex; both genital and ocular plates are bare, smooth and cinnamon color³ on the margins (excepting the distal margins of the oculars) so that the genital plates form a conspicuous star-shaped figure; ocular plates all markedly excluded from the relatively large pentagonal anal system. Actinostome rather large, more than .40 h. d., not noticeably sunken, well covered with rather stout plates, which are hidden by the numerous spines they carry; these spines are long and narrow, with the distal end widened, rounded and curved inward very slightly. Primary spines longer than horizontal diameter of test, nearly cylindrical, fairly stout and blunt; they are densely covered with low, blunt tubercles in about a dozen more or less regular longitudinal series; collar very narrow; secondary spines flat, only a little wider near the base than at the truncate slightly rounded tip; miliary spines, few, very small, acute. No globiferous pedicellariae were found on any one of the specimens; tridentate of two kinds, one with long narrow jaws, are abundant. In color, the test is pinkish cinnamon with the median ambulacral area distinctly light yellowish olive; secondary and miliary spines brownish olive of diverse shades; young primaries Japan rose or slightly darker, in some cases with one or

² *asteriscus*=a little star, in reference to the star-like figure formed by the genital plates.

³ Color names are from Ridgway Color Chart as determined at the time of this study.

two light bands near tip; mature primaries blackish brown except where covered by encrusting bryozoa or other organisms; collar very low, verona brown; primary spines of oral surface light colored, those around the actinostome may be nearly white. The holotype is 26 mm h. d., 13 mm v. d.; longest primaries 35 mm with a diameter near base of nearly 3 mm; at tip, not quite two.

Besides the holotype, there are two other Cidarids that must be referred to this species, as they agree in all essentials. One is nearly as large as the holotype but is badly damaged on one side. The primaries of the oral surface show more red in their coloration and the secondaries are a lighter shade of brown. This specimen was taken with the holotype at *Velero* Station 948-39, March 28, 1939, off Medidor Island, Bahia Honda, Panama, in 30-35 fms on a bottom of mud, rocks and corallines, in company with large numbers of *perplexa*. A third specimen, 15 mm in diameter with primaries 20-26 mm long, is supposed to be from Station 575-36, in the Gulf of California, but there is some doubt as to the reliability of the label. It is unquestionably conspecific with the specimens from Bahia Honda but shows much more red in the coloration and the primaries are not so black as in the holotype. The relationship of this species to *perplexa* is obvious, but to refer these specimens to that species would evidently be quite wrong.

Type.—Holotype, AHF no. 46, 1 paratype.

Type locality.—Station 948-39, off Medidor Island, Bahia Honda, Panama, 30-35 fms, March 28, 1939.

Distribution.—Type locality and the Gulf of California (?).

Depth.—30-100 fms (?).

Specimens examined.—The type, paratype and one other specimen, from 2 stations.

Centrocidaris Doederleini (A. Agassiz)

Plate 38, Fig. 7

Goniocidaris Doederleini A. Agassiz, 1898, p. 73.

Centrocidaris Doederleini A. Agassiz, 1904, p. 33, pl. 14, figs. 1, 2.

Apparently this is a very rare urchin for, in all her collecting, the *Velero* has met with but one specimen—a small adult taken in the Galapagos Islands, near Barrington Island, in 48-73 fms. It is 24 mm in diameter and 13 mm high. The primaries are 20-28 mm long, exceedingly slender, and nearly cylindrical, either smooth or with low, well separated ridges. The abactinal system shows a star-like pattern, as in *Hesperocidaris asteriscus* but in *Centrocidaris* the lines are dark brown with light brown plates instead of the reverse.

Distribution.—Cocos Island, Galapagos.

Type.—U.S.N.M. No. 27348.

Type locality.—Albatross Station 3369, off Cocos Island, 52 fms.

Depth.—48-300 fms.

Specimens examined.—1 specimen.

Order **CENTRECHINOIDA**
Family **Centrechinidae**
Centrechinus mexicanus (A. Agassiz)*
Plate 38, Fig. 8

Diadema mexicanum A. Agassiz, 1863, p. 20.

Centrechinus mexicanus Ziesenhenné, 1937, p. 231.

Diadema mexicanum Mortensen, 1940, p. 275, pl. 60, figs. 7-11.

This big black sea-urchin, with long slender, acutely pointed and very poisonous spines, is a nuisance to bathers, beachcombers and fishermen throughout the tropical Eastern Pacific. Adult specimens are 70-80 mm in diameter with the height of the test about half as much. The primary spines may exceed twice the diameter of the test but they are so very fragile that it is extremely difficult to preserve specimens with the spines unbroken. The secondary spines are very slender and acicular but not very long; when they dry they are so fragile they are easily broken and lost. The absence of spines on the peristome is a constant and striking feature. Full grown individuals are virtually unicolor, black or very dark brown; occasionally definitely brown specimens occur. As in all the species of *Centrechinus* (or *Diadema*) very young specimens have the long spines prettily banded with white and some dark shade, usually purple, but the white is sometimes tinged with brown and the purple is nearly black. With increasing size the white becomes more and more dingy and half grown specimens may have it entirely suppressed and the spines all uniformly dark. Banded spines in specimens half grown or more are common but usually only a few of the primaries show it. The poisonous character of the spines is well known and those who have once suffered the pain which even a single spine can cause, are forever after extremely careful in the vicinity of *Centrechinus*.

Distribution.—This species was taken by the *Velero* at 38 stations, of which the most northern was at Consag Rock in the Gulf of California, the most southern at Gorgona Island, Colombia. The absence of specimens from the western coast of Lower California is notable, since the urchin occurs at both Socorro and Clarion Islands. It is also found at Cocos Island and throughout the Galapagos Islands. It is definitely a shallow water echinoid, for, although it was taken in 40-57 fms at the island, along

*Please see explanation on p. 243.

the mainland coast nearly all the specimens at hand were taken along shore, very rarely in more than 2 fms.

Type.—M.C.Z. no. 635 (Cotype).

Type locality.—Acapulco, Mexico.

Depth.—Shore to 57 fms.

Specimens examined.—191 specimens from 38 stations.

***Astropyga pulvinata* (Lamarck)**

Plate 39, Fig. 9

Cidarites pulvinata Lamarck, 1816, p. 59.

Astropyga pulvinata L. Agassiz and Desor, 1846, p. 345.

Mortensen, 1940, p. 197, pls. 20-23.

One of the characteristic Echini of the warmer Eastern Pacific, this handsome sea-urchin is well represented in the *Velero* collections. There are altogether 165 specimens, ranging in size from 5 mm h. d. with primary spines 7 mm long, to adults 100-117 mm in diameter. The diversity of color is very striking but is brightest in the young which are often very handsome and duldest in the adults. The largest specimen in the present collection is dry and measures 117 mm h. d. and about 40 mm v. d. It is uniformly dark (almost black) above save for the usual large triangular interradiial spots which are light buff but were probably white in life. Apparently this represents the form collected by Mortensen at Contadora Island, Panama, which he designates as variety *venusta* Verrill. The present specimen was taken in 15-20 fms in Tangola Tangola Bay, Mexico, in company with 3 specimens 70-90 mm h. d. which are all typical, handsomely variegated *pulvinata*, as are many other Mexican specimens. A very fine specimen, however, from Tiburon Island, Gulf of California, 10 fms, is almost completely dark violet above, the interradiial spots being scarcely distinguishable and the lower surface being very markedly suffused with violet. This is the most heavily pigmented specimen in the collection though only about 90 mm h.d. Young specimens (17-35 mm) from the Gulf of California, Panama, and Ecuador are very handsome in their variegated liveries of bright red, violet and yellow. It does not seem to me desirable to give varietal names to any of the varied forms, even though such extremes as *venusta* may be recognizable.

Distribution.—This sea-urchin was taken by the *Velero* at some 16 stations along the Mexican and Central American coasts in depths down to 20 fms though many collections were made along shore. The northern-

most stations were at Tepoca Bay, Sonora, where only two very young specimens were taken and Tiburon Island, in the Gulf of California, in 16 fms, where 74 specimens were secured. The southernmost station was at Santa Elena Bay, Ecuador, in 8-10 fms, but no specimens were taken at either Cocos or the Galapagos Islands.

Type.—Paris Museum?

Type locality.—"Habite—probablement les mers de l'Asie."

Depth.—Shore to 20 fms.

Specimens examined.—165 specimens from 16 stations.

***Centrostephanus coronatus* (Verrill)**

Plate 39, Fig. 10

Echinodiadema coronata Verrill, 1867, p. 295.

Centrostephanus coronatus A. Agassiz, 1872a, p. 97.

Mortensen, 1940, p. 314, pl. 36, figs. 7-10.

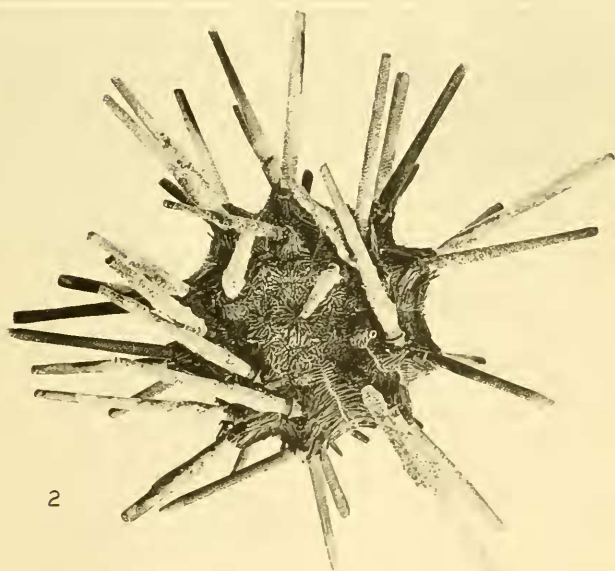
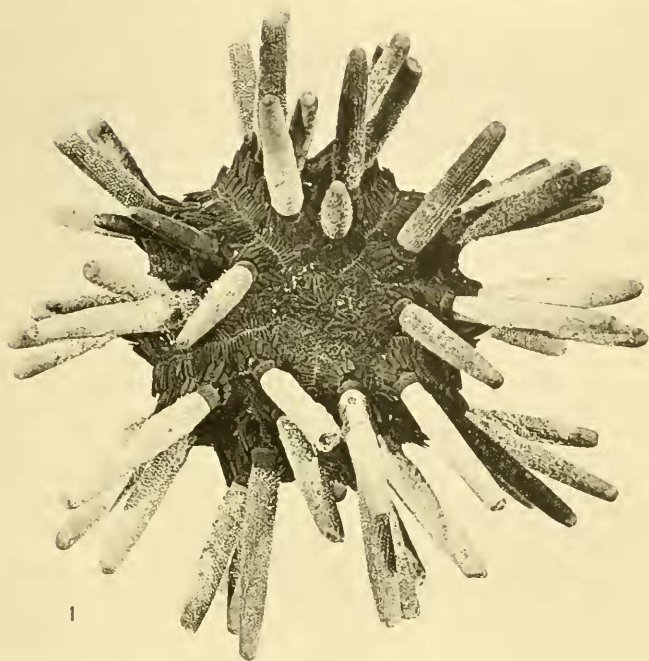
Compared with the preceding two species, this is a relatively small sea-urchin, the largest known specimens being only 63 mm in diameter. The largest of the 131 specimens collected by the *Velero* are only 45-50 mm with the primary spines about twice as much. As the spines are very brittle, especially when dry, few specimens (even in the *Velero* collections, notable for the fine condition of typical specimens in nearly every species) show the handsome appearance of this sea-urchin in life. As in *Centrechinus* the spines are finely verticillate and very acute but there is no evidence that they carry poison at the tip as do those of *Centrechinus*. A very interesting character of this *Centrostephanus* is the presence on the uppermost interambulacral plates of short claviform spinelets the tips of which are bright red purple. This color persists in most preserved specimens but may be much duller and hence less noticeable than in life. Mortensen discovered that these spinelets are never resorbed or replaced by the long primary spines but the latter grow up around them and enclose them without resorption. Young individuals of this *Centrostephanus* are so similar to young examples of *Centrechinus mexicanus* that they are often confused with them but there are three characters by which the two species may be readily distinguished. The most important of these is the presence of these brightly tipped claviform spinelets in *Centrostephanus* which are never present in *Centrechinus*. A second distinctive character is the presence of slender, blunt, light-colored spinelets on the five pairs of oral plates around the mouth (in *Centrechinus* these plates may have pedicellariae but never spinelets). The third difference is in the color of

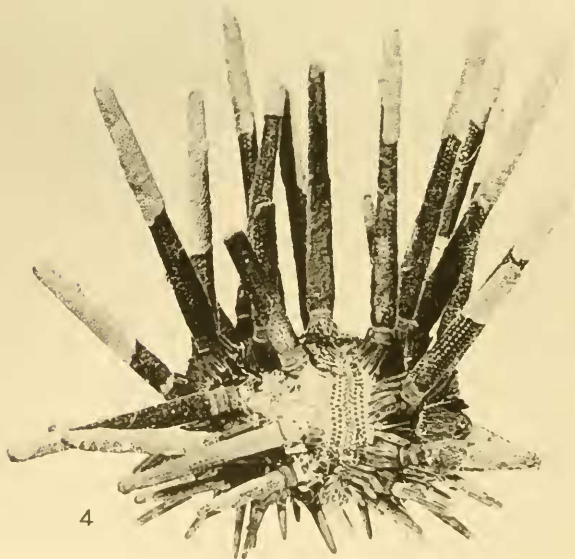
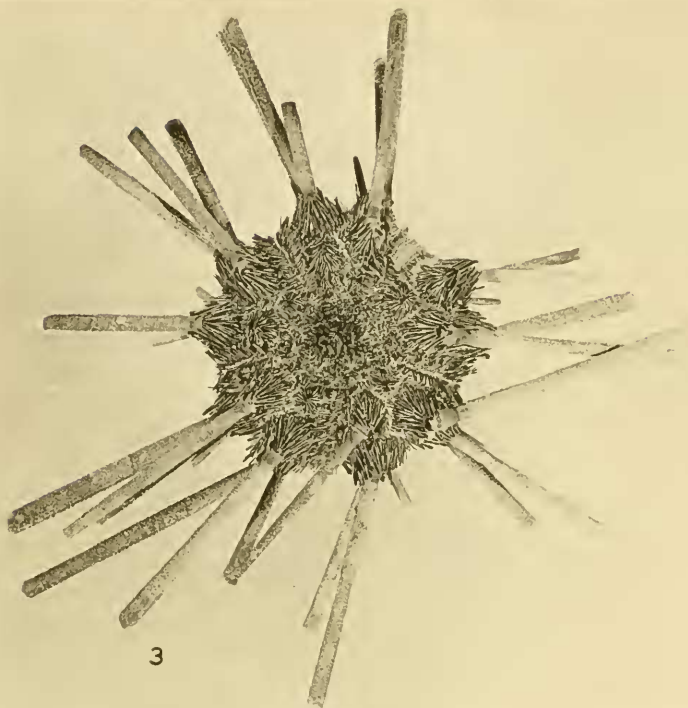
PLATE 35

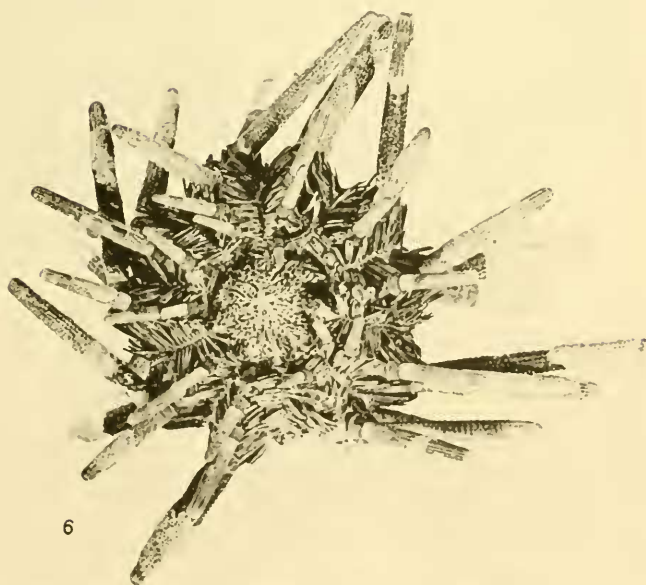
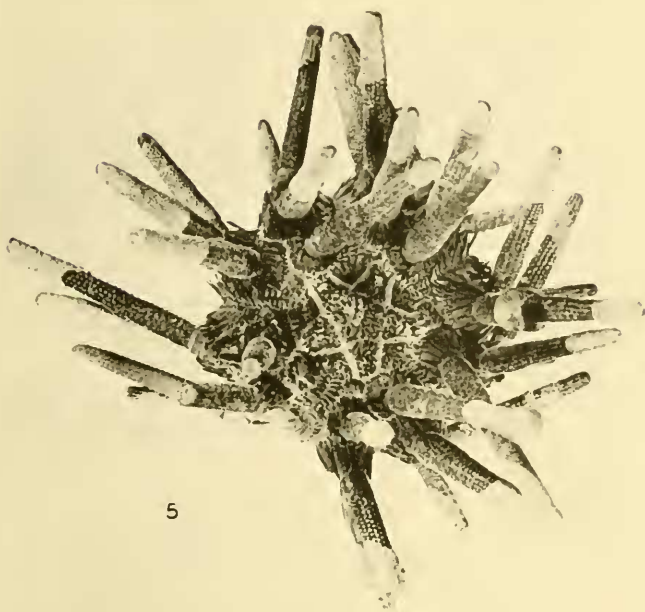
- Fig. 1. *Eucidaris Thourasii* (Valenciennes), aboral view, $\times\frac{2}{3}$, p. 229
Fig. 2. *Hesperocidaris panamensis* (A. Agassiz), aboral view, $\times\frac{2}{3}$, p. 230

PLATE 36

- Fig. 3. *Hesperocidaris perplexa* (H. L. Clark), aboral view, $\times\frac{2}{3}$, p. 231
Fig. 4. *Hesperocidaris asteriscus*, new species, lateral view, $\times\frac{4}{3}$, p. 232







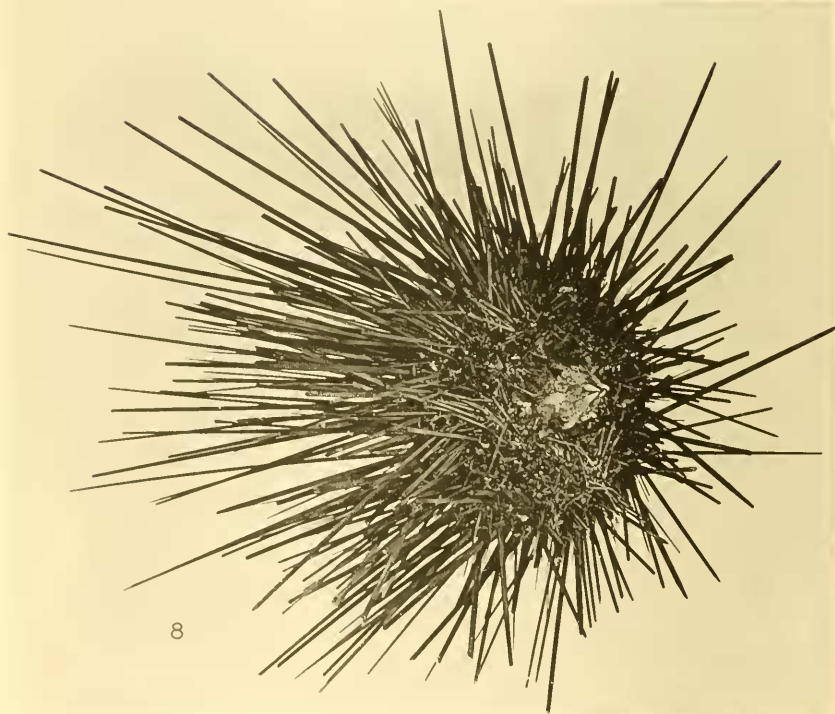
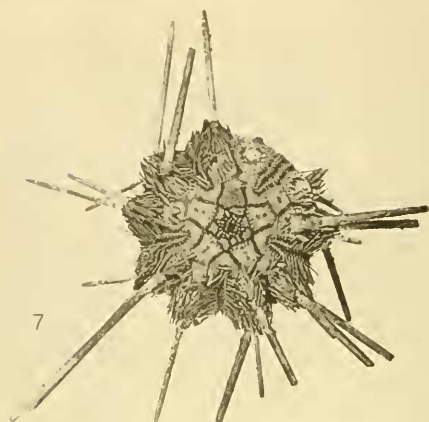


PLATE 37

Fig. 5. *Hesperocidaris asteriscus*, new species, aboral view, $\times\frac{4}{3}$, p. 232

Fig. 6. *Hesperocidaris asteriscus*, new species, oral view, $\times\frac{4}{3}$

PLATE 38

Fig. 7. *Centrocidaris Doederleini* (A. Agassiz), aboral view, $\times 1$, p. 234

Fig. 8. *Centrechinus mexicanus* (A. Agassiz),* oral view, $\times\frac{1}{2}$, p. 235

*In a recent letter from Th. Mortensen he states that The International Commission on Zoological Nomenclature meeting in Paris this summer (1948) rendered an Opinion which codified the name *Diadema* as a *nomen conservandum*.

This species is, therefore, *Diadema mexicanum* A. Agassiz, order Diadematoida, family Diadematidae. These corrections replace corresponding names used on p. 235 of the text.

the primary spines; in young *Centrechinus* the spines are banded bluish or purplish and white, in *Centrostephanus* dull purplish brown and light yellow. With increasing age and size, the colors become duller until the mature primaries are uniformly black in *Centrechinus*, dark brown in *Centrostephanus*. It is unusual for banded spines to be evident in adults of either genus but carefully preserved alcoholic specimens of *Centrostephanus*, even when full grown, commonly show the banding on some primaries at least, though faintly. Most dry specimens, however, appear to be more or less uniformly dark brown or quite black. On the contrary, very young specimens (less than 10 mm in diameter) are unusually pretty objects, the test and small spines deep brown, the dull yellow primaries more or less evidently banded with purplish brown, and five or more claviform spinelets, with bright rose-purple tips around the apical system.

Distribution.—This species of *Centrostephanus* is definitely a shallow water Mexican sea-urchin but the *Velero* took it at five stations in the Galapagos Islands. At Albemarle Island it was found in shallow water but off James Island it occurred in 36-60 fms. It was not met with at either Cocos or the more northern islands (Socorro and Clarion), or on the west coast of Lower California. Yet it is frequently found at Newport and Corona del Mar, California, near low water mark. It has yet to be taken on the mainland coast south of the Gulf of California but in the Gulf it has been found as far north as Rocky Point, Sonora, and Consag Rock, in depths down to 45 fms.

Type.—Peabody Museum, Yale University, no. 964.

Type locality.—Cape San Lucas, Lower California.

Depth.—Shore to 60 fms.

Specimens examined.—131 specimens from 37 stations.

Family **Arbaciidae**
Arbacia incisa (Blainville; ? Gmelin)

Plate 40, Fig. 11

Echinocidaris incisa A. Agassiz, 1863, p. 20.

Arbacia incisa H. L. Clark, 1913, p. 220.

Arbacia stellata Mortensen, 1935, p. 575, pl. 70, figs. 6-9.

This is one of the commonest sea-urchins of the Gulf of California and was taken by the *Velero* at many stations there. Along the coast southward it seems to be less common and relatively few specimens were secured but unmistakable examples were collected as far south as Peru. Indeed one of the largest specimens in the collection, 47 mm h.d., was taken nine miles south of Zorritos Light, in shore collecting; from tip to

tip of the extended spines it measures 120 mm. Mortensen refers to the "largest size recorded for this species is 60 mm diameter" but he does not give his authority for this giant.⁴ Only a very few of the *Velero's* 1,121 specimens exceed 35 mm h. d. (the largest is 56) and a very large number are less than 20 mm across. Very young specimens (2-8 mm h. d.) are as a rule light colored more or less flesh red, becoming red brown, or violet or deep purple, until finally they are nearly or quite black. A few dry specimens are more or less definitely gray. One curious variety has some of the primaries, or at least portions, quite pink or white in striking contrast to the black of the remaining spines and test. Mortensen (p. 566) makes the "conspicuous red spots in the interambulacra on the aboral side" the distinguishing mark of the species and the *Velero* collection confirms his judgment. Even in the most nearly black adults, careful examination in good light will show at least faint indications of the tell-tale red blotches. Young individuals with the test flesh color or red and the red spines with one or more whitish bands are so different from the more mature specimens, it is hard to believe they can ever become as dark colored as they do, but the present large series compels the acceptance of the fact. In one or two of the very black specimens there is real difficulty in seeing any red, but such individuals cannot be distinguished satisfactorily as anything other than excessively pigmented *incisa*.

Mortensen's (1935, p. 577) plea for the specific name *stellatus* is inadequate, and if we once let such arguments control our decisions we shall have more disagreements and resulting confusion than we have had hitherto. Nobody knows to what sea-urchin the name *stellatus* was first given. Everyone knows what *Echinocidaris incisa* was at the start and there has never been any confusion about it, so I have no hesitation in continuing the use of the name here.

Distribution.—The *Velero* collections show that this is essentially a species of the Gulf of California. It ranges north to the southern United States as shown by Ziesenhenné (1941, pp. 117-120). There are 6 very fine adult specimens in the *Velero* collection from Newport Harbor, California, but the *Velero* has taken no other specimens north of Lower California, nor along its western coast. South of the Gulf, *incisa* does not appear to be very common though there are specimens at hand from Bahia Honda, Panama; Gorgona Island, Colombia; Santa Elena Bay and La Plata Island, Ecuador; Zorritos Light, South Bay, Lobos de Afuera,

⁴ The authority for this giant is Clark himself, who says in his Echinoderms of Peru, p. 345, that "large specimens may be 60 mm in diameter." TH. MORTENSEN

and Middle Chincha Island, Peru. The last is the farthest south for *incisa*, 13° 39' 15" S. All stations are in shallow water, less than 50 fms and almost always less than 20. A very small specimen is labeled as from Station 1105-40 in the Gulf of California, with a depth of 113-127 fms. It is probable that this individual was actually dredged at Station 1101-40, but was lost in the meshes of the dredge until the careful search after a deep water haul. It is notable that no specimens of *incisa* were taken at the Galapagos Islands, Cocos, Clarion or Socorro Islands, nor along the Costa Rican coast, though it has been previously recorded from the Galapagos.

Type.—M.C.Z. no. 467 (Cotype).

Type locality.—Guaymas, Lower California, Mexico.

Depth.—Shore to 50 fms.

Specimens examined.—1,121 specimens from 82 stations.

Arbacia spatuligera (Valenciennes)

Plate 40, Fig. 12

Echinus (Agarites) spatuliger Valenciennes, 1846, pl. 5, fig. 2.

Arbacia spatuligera A. Agassiz, 1872a, p. 93.

H. L. Clark, 1910, p. 346, pl. 10, fig. 2.

Mortensen, 1935, p. 577, pl. 70, figs. 1-5.

Adult specimens of this rather handsome sea-urchin are said to reach a test diameter of 70 mm but the finest of the 15 specimens secured by the *Velero* are barely 50 mm h. d. and the longest spines scarcely exceed 40 mm. These large specimens (30-50 mm h. d.) are brown, very dark on the test but with the spines much lighter, a real fawn brown. Small specimens (15-25 mm h. d.) are dark; the smaller has the interambulacra definitely tinged with green and the spines are dull pink or rose, brightest on the lower surface; the larger (25 mm h.d.) has the dark interambulacra scarcely tinged with green and the primary spines dark violet. A series of 5 very small *Arbacias* from Sechura and Independencia Bays, Peru, are pale gray or whitish or reddish brown, with the primary spines either colorless or with one or two light red bands. While it is not certain that these little *Arbacias* are young *spatuligera*, there is little reason to doubt it.

Distribution.—Even including the very small *Arbacias* just mentioned, the *Velero* material throws no new light on the distribution of *spatuligera*. The largest specimens are from San Lorenzo Island, Peru in 5 fms. The remaining material is from Sechura and Independencia Bays in water 10 fms deep or less. So far as the *Velero* collections are concerned this *Arbacia* is found only in Peru.

Other records, however, extend its range to Ecuador and Chile.

Type.—Unknown.

Type locality.—"Carthagena on the west side of the Isthmus of Darien." (Panama)

Depth.—Shore to 10 fms.

Specimens examined.—16 specimens from 6 stations.

Tetrapygus niger (Molina)

Plate 40, Fig. 13

Echinus niger Molina, 1782, p. 200.

Tetrapygus niger A. Agassiz and H. L. Clark, p. 73.

H. L. Clark, 1910, p. 345, pl. 10, fig. 1.

Mortensen, 1935, p. 582, pl. 70, figs. 10-12.

This is one of the most characteristic of the sea-urchins of the South American Pacific coast for it is primarily a Peruvian species and has not yet been found north of the equator nor at the Galapagos Islands. The *Velero* collection contains 274 specimens. Over 250 of these were found along shore and are for the most part adult; few are less than 15 mm h. d. Only at Fronton Island, near Callao, in 5 fms, were specimens of *niger* dredged. The color of the adults is dull black; small specimens (under 25 mm) tend to be more brownish but not markedly so. South of Peru, *niger* ranges far down on the Chilean coast but its northern limit is near Payta, Peru. At the Lobos de Afuera Islands it is very common. Other authors include Chile and Patagonia in the range.

Type.—Unknown.

Type locality.—Chile.

Depth.—Shore to 5 fms.

Specimens examined.—274 specimens from 9 stations.

Family **Echinidae**

Lytechinus anamesus H. L. Clark

Plate 41, Fig. 14

Lytechinus anamesus H. L. Clark, 1912, p. 254, pl. 107, figs. 7-11.

Mortensen, 1943, p. 452, pl. 23, figs. 33-40.

Apparently the commonest sea-urchin in moderate depths off the southern California coast, this rather attractive small species was taken by the *Velero* at no fewer than 155 stations at depths of 8 to 160 fms. Altogether 5,090 specimens were secured, the largest 37 mm in diameter. When very young it is light colored, often quite white, more often cream

color, but by the time it is 8-10 mm across, spots and blotches of gray or dull green have begun to appear and in mature specimens, 20-30 mm across, the upper surface may be more or less dull colored with spots or blotches of cream color. The slender, more or less acicular, spines are unicolor, generally cream color or even white, but the smaller ones are often gray. In many specimens, however, the primary spines are yellowish brown or even rust color, and in others they are dull gray. From some stations the specimens are so dark as to be easily confused with *pictus*. This is most apt to be the case with material from the deeper water stations, much of the test and most of the spines being dull greenish gray; in such specimens the spines are apt to be shorter and blunter than usual, and the resemblance to the following species may be confusing. The differences will be emphasized under *pictus*. Very young specimens of *anamesus* are almost pure white or very pale yellow and the primary spines are often conspicuously long and acicular. Before the test is 10 mm in diameter, a dull colored spot begins to appear at the upper end of each interradiar area and these are soon followed by others until in adult specimens the whole upper surface of the test is conspicuously blotched with the darker shade. At the same time primary spines also take on the dull color, in more or less marked contrast with their fellows. As already stated some individuals, and at some stations all, are so dark as to be difficult to recognize as *anamesus*. Occasionally individuals are met with of so dark a brown as to make identification difficult but the relatively long acicular spines are distinctive in most of such cases. Not rarely specimens 12-15 mm in diameter are met with which have developed no pigment but are uniformly white or cream color. As a rule, however, pigmentation begins very soon after the test is fully formed.

Distribution.—The remarkably limited range of this sea-urchin is notable for the thousands of specimens taken by the *Velero* are convincing proof that it is a very common species off the coast of southern California and the adjoining islands, as far south as Station 283-34 off Thurloe Head, Lower California ($27^{\circ} 37' 30''$ N). It was not taken north of Station 1410-41 ($34^{\circ} 53' 35''$ N), 3 miles east of the southern point of Santa Rosa Island, in 17-20 fms. It was seldom taken in less than 20 fms, the least depth being in 8-10 fms, at the southernmost station, off Thurloe Head. The greatest depth was at 160 fms at Station 1182-40, near Catalina Island. This distribution is strikingly similar to that of the 414 specimens on which the species was based. The *Albatross*

took them at 25 stations between $28^{\circ} 12' N$ and $34^{\circ} 24' 30'' N$ at depths of 20-113 fms, including Guadeloupe Island.

Type.—U.S.N.M. No. 32660.

Type locality.—Albatross Station 2930, off San Diego, 60 fms.

Depth.—8-160 fms.

Specimens examined.—5,090 specimens from 155 stations.

Lytechinus pictus (Verrill)

Plate 41, Fig. 15

Psammechinus pictus Verrill, 1867, p. 301.

Lytechinus pictus H. L. Clark, 1912, p. 258, pl. 107, figs. 12-14.

This species has undoubtedly been confused with the preceding and the suggestion has been made that the two are identical but show great diversity. The thousands of specimens of *anamesus* taken by the *Velero* are supplemented by some 488 specimens of *pictus*, ranging from 2 to 38 mm in diameter. When young the two species are so different they could not be confused but mature specimens may look very much alike. Young *anamesus* are pure white with long, acicular white spines. As they mature the color becomes more yellowish, and blotches of gray or dull purple appear on the upper side of the test, but there is no hint of red or violet on either test or spines. When adult, the slender, acute, unbanded spines are quite different from the relatively short, rather thick, blunt spines of *pictus*. In specimens of *pictus* less than 8 mm in diameter the primary spines of the oral side at least are definitely reddish, ranging from dull pink to a clear rose purple, with one or more definitely white bands. In some cases the bands are not evident but there is more or less red or rose purple evident on at least the distal part of the spines, but after the test is more than 10 mm in diameter the spines are unicolor, gray, brown or red purple. Often the basal half is nearly white, the distal half more or less dull rose or dull yellow. In young specimens there is usually rose purple or violet evident on the abactinal system but this soon disappears and the whole system becomes a dull gray. Young *pictus* with banded rose purple spines may be easily confused with young *Strongylocentrotus purpuratus*, but in *Lytechinus* the color is much more pink than in *purpuratus*. In *anamesus* there is never any pink or rose purple shade in the coloring of the spines but yellow, yellow brown or dull orange may be marked; usually the shades are dull gray or olive when not yellowish or brown; on the oral surface the spines are commonly white. In *pictus* there is usually no white on the oral side but some individuals are as white as any *anamesus*.

PLATE 39

- Fig. 9. *Astropyga pulvinata* (Lamarck), aboral view, x approx. $\frac{2}{3}$,
p. 236
Fig. 10. *Centrostephanus coronatus* (Verrill), aboral view, x approx.
 $\frac{1}{2}$, p. 237

PLATE 40

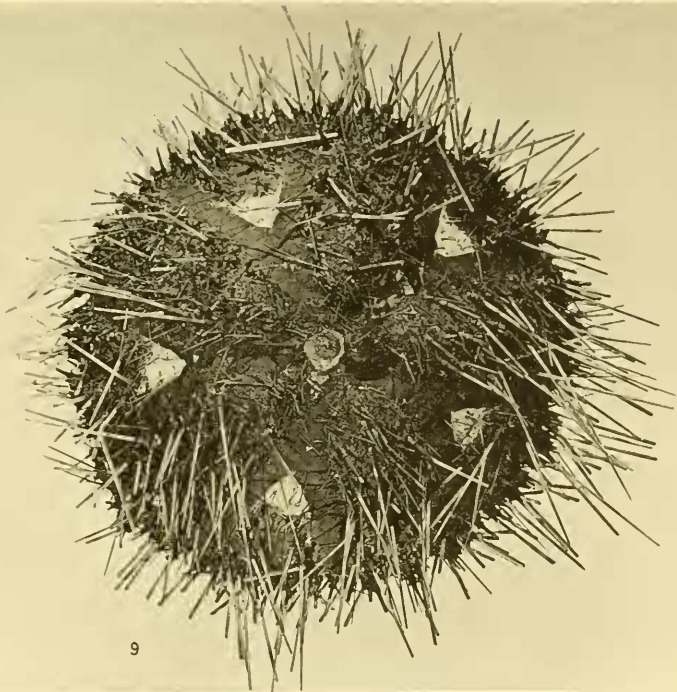
- Fig. 11. *Arbacia incisa* (Blainville, ? Gmelin), aboral view, x $\frac{2}{3}$,
p. 244
Fig. 12. *Arbacia spatuligera* (Valenciennes), aboral view, x $\frac{2}{3}$, p. 246
Fig. 13. *Tetrapygus niger* (Molina), aboral view, x $\frac{2}{3}$, p. 247

PLATE 41

- Fig. 14. *Lytechinus anamesus* H. L. Clark, aboral view, x1, p. 247
Fig. 15. *Lytechinus pictus* (Verrill), aboral view, x1, p. 249
Fig. 16. *Lytechinus semituberculatus* (Valenciennes), aboral view,
x1, p. 261

PLATE 42

- Fig. 17. *Toxopneustes roseus* (A. Agassiz), aboral view, x1, p. 262
Fig. 18. *Tripneustes depressus* A. Agassiz, aboral view, x $\frac{2}{3}$, p. 263

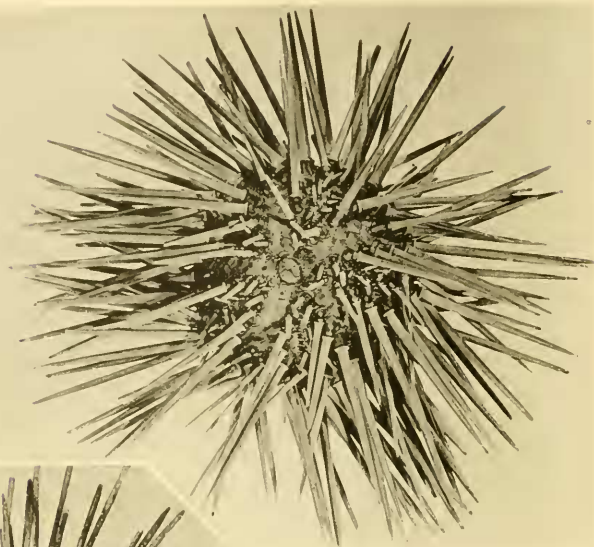


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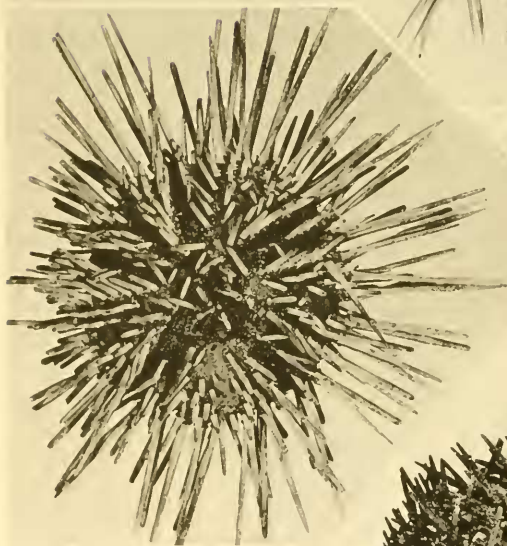


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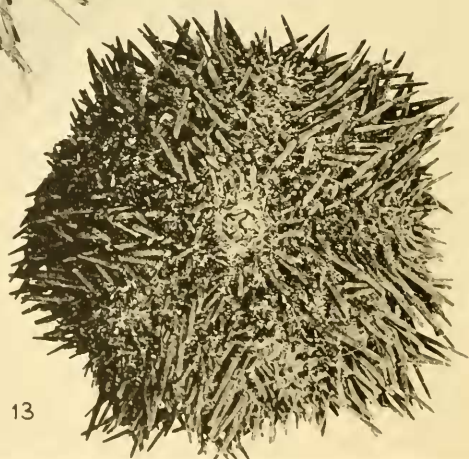
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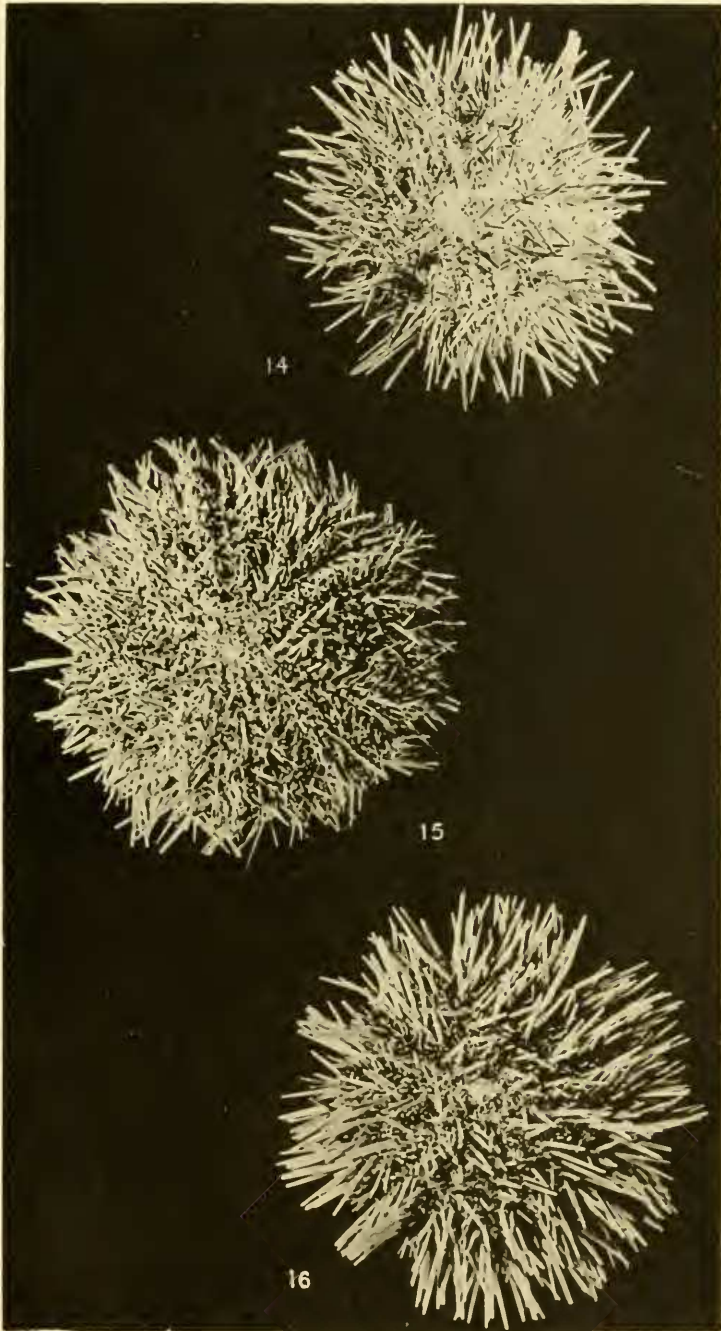


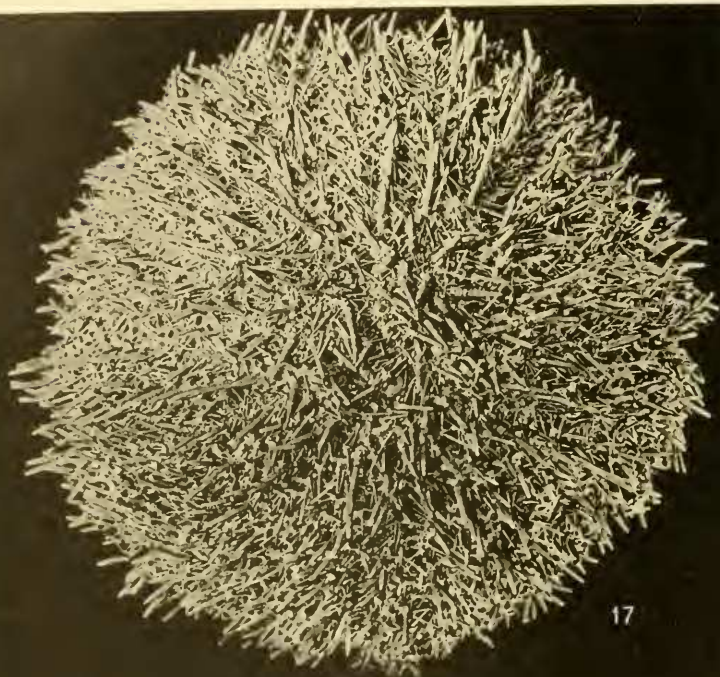
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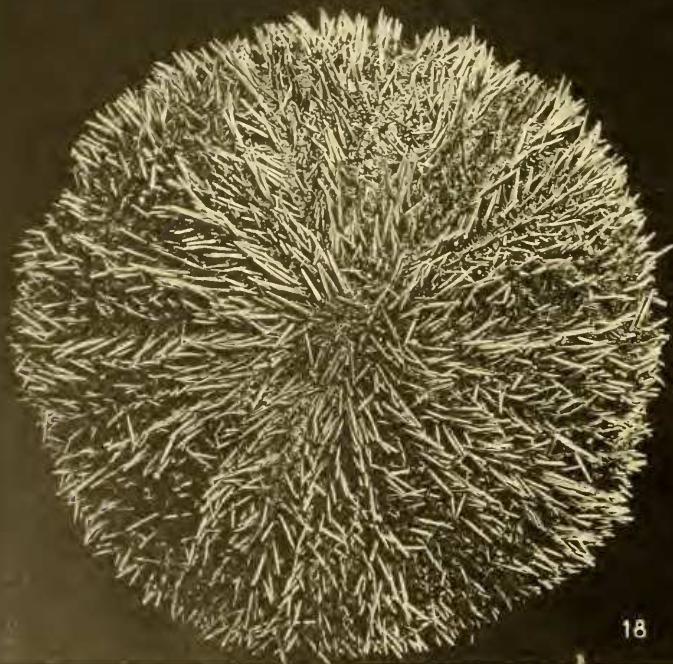
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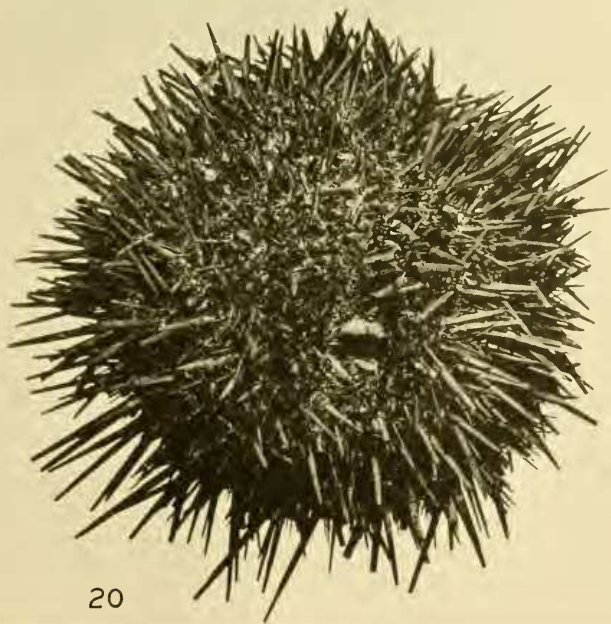
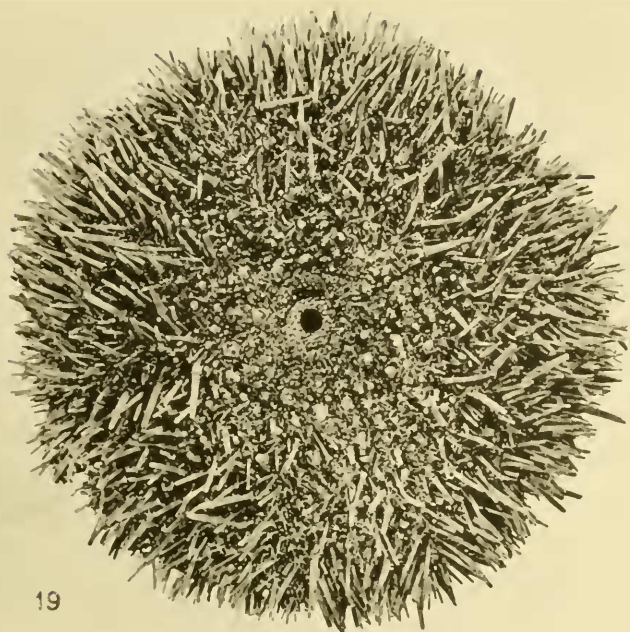


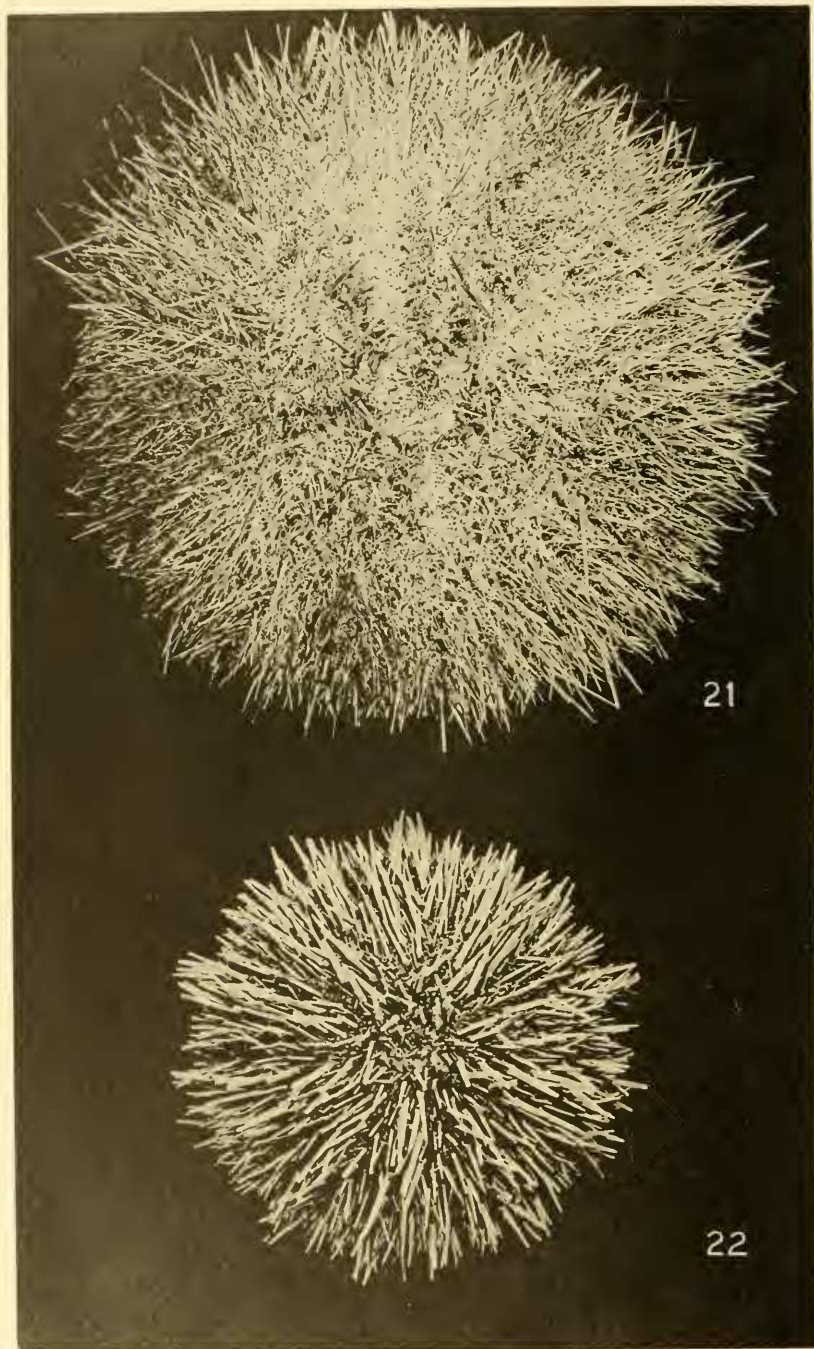


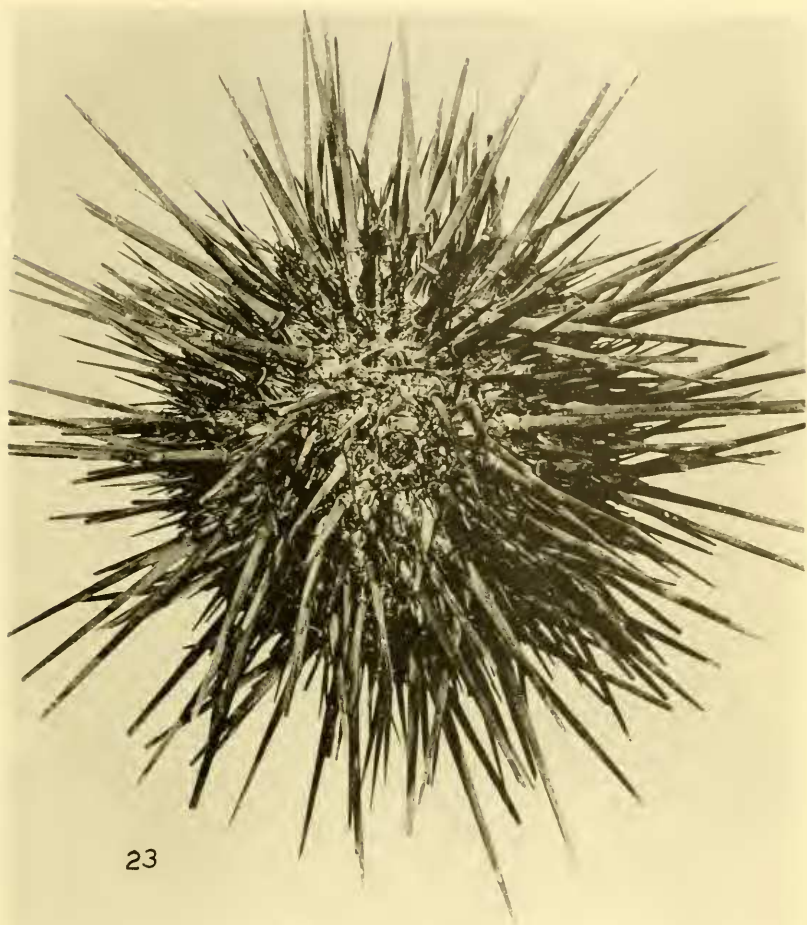
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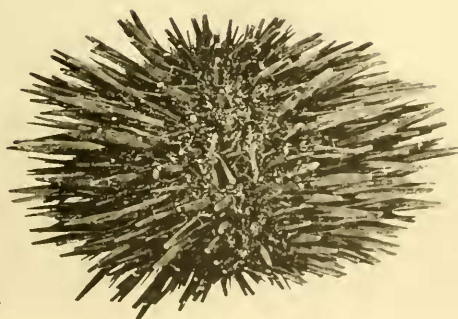
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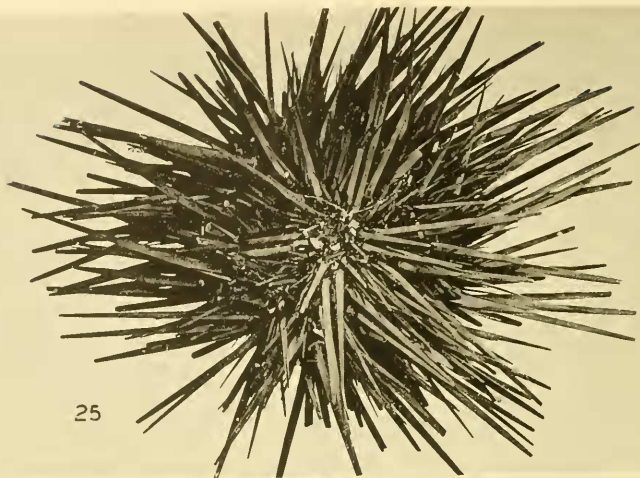




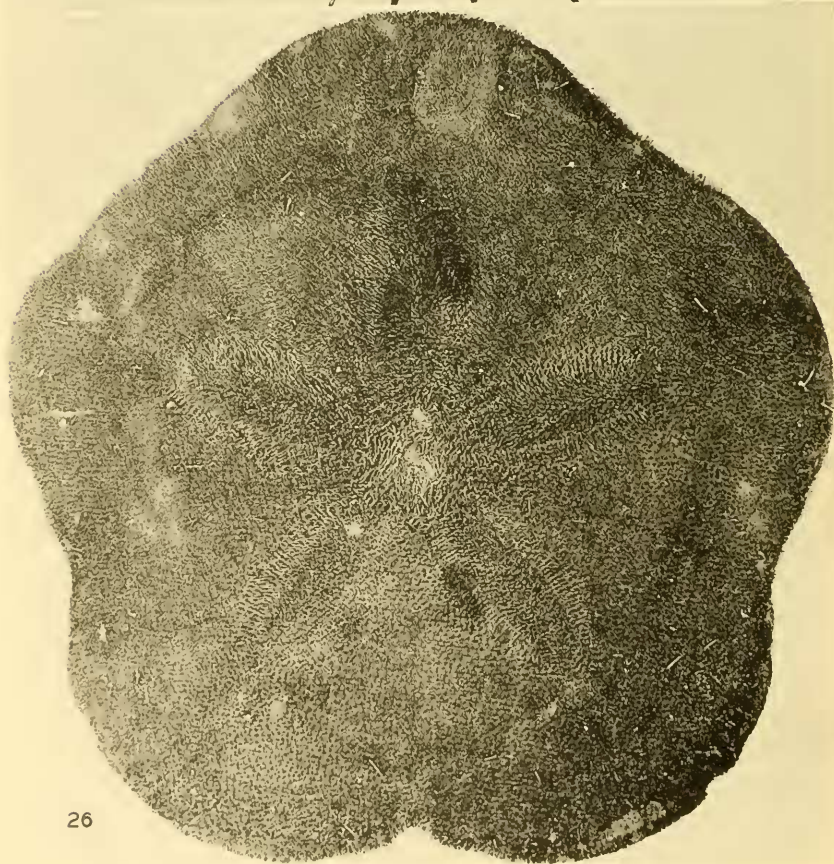
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PLATE 43

- Fig. 19. *Loxechinus albus* (Molina), aboral view, x1, p. 265
Fig. 20. *Caenocentrotus gibbosus* (L. Agassiz and Desor), aboral view, x1, p. 265

PLATE 44

- Fig. 21. *Allocentrotus fragilis* (Jackson), aboral view, x1, p. 276
Fig. 22. *Strongylocentrotus purpuratus* (Stimpson), aboral view, x1, p. 279

PLATE 45

- Fig. 23. *Strongylocentrotus franciscanus* (A. Agassiz), aboral view, $\times\frac{7}{8}$, p. 278
Fig. 24. *Echinometra oblonga* (Blainville), aboral view, x1, p. 281

PLATE 46

- Fig. 25. *Echinometra VanBrunti* A. Agassiz, aboral view, $\times\frac{2}{3}$, p. 293
Fig. 26. *Clypeaster europacificus* H. L. Clark, aboral view, $\times\frac{2}{3}$, p. 294

Aside from color and character of the spines, it is hard to find any very tangible differences between the two species. On the whole the number of coronal plates and of large tubercles is greater in *pictus* than in *anamesus*. Specimens 25 to 30 mm h. d. having about 20 interambulacral plates in a column, have in *pictus*, 27 or 28 ambulacrals, in *anamesus* about 20 or 21. In the same specimens, *pictus* has 4 large primary tubercles on each coronal plate just below the ambitus, while in *anamesus* there are but 3 tubercles. Furthermore, the interambulacral areas above the ambitus obviously carry fewer tubercles in *anamesus* than in *pictus*. Mortensen (1943, pp. 437, 450) had no specimens of *pictus* available for critical study but saw Verrill's type and cotype at New Haven. He describes them as "light purple with radiating whitish bands, the spines bright purple, more or less distinctly banded." In all the hundreds of *Lytechinus* from the southern California coast, no specimen with any definitely purple tint has been seen. Neither has any individual with "spines bright purple, more or less distinctly banded" been detected. The difficulty is probably due to misunderstanding in the use of color terms. Mortensen's "purple" is probably what to me is "rose violet," but none of the *Lytechinus* at hand could by any possibility be called "bright" colored.

Distribution.—The 42 stations at which *pictus* was taken by the *Velero* are widely scattered and show a perplexing distribution. Some of the best material has been secured at Newport, Balboa, and Corona del Mar, California, at or near low water mark and a few specimens have been taken at or near the Channel Islands in moderately deep water, 3-39 fms. But most of the specimens are from stations in the Gulf of California usually in rather deep water, 40-95 fms. Much further south some very small Echini have been taken which are best treated as *pictus*. Half a dozen were secured at La Plata, Ecuador, 7-10 fms, which may possibly be Mortensen's *panamensis* but their very small size prevented satisfactory determination. A single specimen from Gorgona Island, Colombia, in 20 fms and one from Bahia Honda, Panama, 5-8 fms offer the same difficulty. They may possibly be *panamensis* but it is not wise to assert that they are.

Type.—Peabody Museum, Yale University, no. 961.

Type locality.—"Cape San Lucas, California" (Grant and Hertlein, 1938, p. 25).

Depth.—Shore to 95 fms.

Specimens examined.—488 specimens from 42 stations.

Lytechinus semituberculatus (Valenciennes)

Plate 41, Fig. 16

Echinus (Psammechinus) semituberculatus L. Agassiz and Desor, 1846, p. 368.

Lytechinus semituberculatus Verrill, 1867, p. 301.

Mortensen, 1943, pp. 456-459, pl. 26, figs. 5, 6.

This well marked species is represented in the *Velero* collection by 863 specimens, but it should be stated at once that 570 of them are bare tests from a sand beach adjacent to lava rock at Bindloe Island, Galapagos Islands. The largest specimen at hand is 43 mm in diameter but most of them are considerably less than that. The yellow green color of the primary spines is very characteristic of well grown specimens, but very young individuals, 5 mm or less in diameter are bright vermilion red or paler, even a simple cream color with the median interambulacra apically deep green. Individuals 8-15 mm h. d. are often very handsome with the test deep green above and more or less pure white beneath; the dorsal half of each interambulacrum may be deep red in sharp contrast with the vermilion red and white of the ambulacra. The apical system in such specimens is greenish with a few vermilion red spots. In some young individuals the red may be very pale except orally, and in others it may be wholly wanting, the resulting green and white livery being soon replaced by the brownish test and long green spines of the adult. In youth the green shades are rich and rather dark and more or less mixed with white but with increasing size the white as well as the red tends to disappear. It is hard to believe that the really beautiful red, green, and white young urchins can so soon and so completely lose their beauty and become the uniformly dull brown or blackish adult covered with uniformly yellow-green spines. Some adults have the spines tinged at the tip with yellow brown and rarely the color of a dried specimen may be definitely brown with little indication of green. In the great majority of museum specimens, however, the characteristic yellow green or light green shade of the primaries is unmistakable.

Distribution.—This urchin is one of the most typical of Galapagos echinoderms. The *Velero* took it at 43 stations in the archipelago; 10 times near Charles Island, 8 near James, 6 at Albemarle, 5 at Hood, 4 at Indefatigable, 3 near South Seymour, 3 at Barrington and one each at Bartholomew, Bindloe and Tower. Not a specimen has been secured at Cocos

Island or anywhere along the American coast. Mortensen reports it "with full certainty" from Clarion Island⁵ but the *Velero* visited that isolated island twice and made 17 hauls of the dredge, besides two collecting trips along shore, and failed to find a single specimen. Certainly it should be found on the rich collecting ground at Cocos Island, if it occurs north of the Galapagos. If it is found on the American coast anywhere it is strange that the *Velero* has not met with it. It may be added that Dr. Coker did not find it on the Peruvian coast during his stay there (1907-1908) nor did the Templeton-Crocker Expedition secure any specimens at Clarion Island in 1936. There seems no adequate reason for doubting that this sea-urchin occurs only at the Galapagos Islands.

Type.—Paris Museum.

Type locality.—Galapagos Islands.

Depth.—Shore to 73 fms.

Specimens examined.—863 specimens from 43 stations.

***Toxopneustes roseus* (A. Agassiz)**

Plate 42, Fig. 17

Boletia rosea A. Agassiz, 1863, p. 24.

Toxopneustes roseus Mortensen, 1903, p. 111.

Grant and Hertlein, 1938, p. 26, pl. 17, figs. 1, 2.

Mortensen, 1943, p. 483, pl. 31, figs. 1-5.

Not a very common sea-urchin of the Panamic region, this large and striking species was not often secured by the *Velero*; only in 1933-34, 1934-35, 1938 and 1939 were specimens taken. Of the 22 specimens at hand, 14 are from Panama, near Secas Islands, in 3 fms. Of the remaining 8, 3 are very small (15-23 mm in diameter) and only one is more than half grown. Even the smallest is easily distinguished by the relatively huge and commonly widely open globiferous pedicellariae. The extraordinary appearance of the living sea-urchin is admirably shown in Mortensen's figures of the closely related species, *pileolus* (1943, pl. 26, fig. 3 and pl. 27, fig. 2). No other sea-urchin gives any such display of pedicellarian power as does *Toxopneustes*. The western Pacific species of

⁵ The expression "with full certainty" quoted from my Monograph (p. 459) refers to the identification of the specimens of *L. semituberculatus* from Clarion Island mentioned by Clark in his catalogue of Recent Sea-Urchins in the Coll. of the British Museum, p. 120, the identification of other specimens being uncertain, as pointed out both by Clark and myself. The locality Clarion Island of the specimens in the British Museum may be erroneous.

the genus are also interesting for their coloration which is notably varied and inconstant, but the Panamic species is unicolor, more or less rose or, according to Mortensen "light purple." Preserved specimens are dull yellowish brown or the test may show a definitely purplish tint. Very young specimens are yellowish, with spines and the big widely opened pedicellariae, white. So far as preserved material is concerned the name *roseus* is most inappropriate.

Distribution.—The *Velero* took *Toxopneustes* at only 7 stations. The northernmost was at Port Culebra, Costa Rica, in 3-10 fms. The southernmost was at La Plata Isle, Ecuador, in 4 fms. The young specimens referred to above, 15-23 mm in diameter, were found at Port Utria, Colombia. A small adult was found at Braithwaite Bay, Socorro Island, in 20 fms and a somewhat larger individual was collected at Sullivan Bay, James Island, Galapagos Islands, at the same depth. This is the only record from the Galapagos Islands but there is apparently no doubt about either the locality or the identification. It is remarkable that *Toxopneustes* has not been taken on the Mexican coast or at Cocos Island. It is difficult to see why it does not occur north of Costa Rica but except for the *Velero's* specimen from Socorro Island and Mortensen's statement of its occurrence at La Paz, there are no records from the Mexican coast or islands. Neither the *Velero* nor the Templeton-Crocker Expedition found even one specimen in the Gulf of California.

Type.—No type.

Type locality.—Acapulco, Mexico.

Depth.—2-30 fms.

Specimens examined.—22 specimens from 7 stations.

***Tripneustes depressus* A. Agassiz**

Plate 42, Fig. 18

Tripneustes depressus A. Agassiz, 1863, p. 24.

Mortensen, 1943, p. 498, pl. 35, figs. 1, 2; pl. 38, fig. 9.

The largest regular sea-urchin of the western coast of tropical America this species reaches a horizontal diameter of 150 mm. There is great diversity in form, for while the height is usually a little more than half the diameter, the specimen 150 mm horizontally is only 72 mm vertically, and a specimen 138 mm across is only 65 mm high. On the other hand a specimen 127 mm across is 83 mm high. The height of the test thus ranges

from 47 to 65 per cent of the diameter. Growth changes from 30 mm h. d. to 150 mm are chiefly in the number of secondary and miliary tubercles (and spines, of course). In the young individuals, there are two columns of primary tubercles in the ambulacra and two in the interambulacra, with secondary and miliary tubercles present between them in the interambulacra in not very well-marked series. On the ambulacra there are few tubercles of any importance in the interporiferous area save for one column on each side. In an adult, 100 mm or more in diameter, there are 10-12 well-spaced columns of primary tubercles and many well-scattered smaller tubercles in the interambulacra. The ambulacra have undergone a more marked change; 4-6 imperfect columns of primary tubercles occupy the interporiferous area, and the poriferous areas have themselves widened markedly and carry 3 or 4 columns of tubercles mixed with irregularly scattered tube-feet between an inner and outer column of tube-feet which sharply delimit the area. The scattered tube-feet are much more numerous on the inner side of the area than on the outer. As for color, the dry specimens are very unattractive, as they were obviously prepared in haste. The test is almost black but with purple tinge more or less evident, and the spines are pale brown or brownish-white. One small adult in alcohol gives a better idea of the color in life. The test is purple, lightest on the poriferous areas, darker and duller on the interambulacra and on the interporiferous areas of the ambulacra. The spines are white in marked contrast to the test.

Distribution.—The 63 specimens of *depressus* brought in by the *Velero* are, with only two exceptions, from outlying islands. The exceptions are from the shores of Secas Islands, Panama. Of the other 61 specimens, 7 are from the Galapagos Islands (Albemarle, Tower, Chatham, Charles, and Gardner), all from along shore except the half grown specimen from near Gardner Island which was dredged in 12 fms. Of the remaining specimens 43 are from Socorro and 11 from Clarion, all secured by collecting along shore. The type locality is said to be Guaymas, Mexico, but it is notable that neither the *Velero* nor the Templeton-Crocker Expedition found any *Tripneustes* in the Gulf of California nor on the Mexican coast.

Type.—No type.

Type locality.—Guaymas, Mexico.

Depth.—Shore to 12 fms.

Specimens examined.—63 specimens from 10 stations.

Family **Strongylocentrotidae**
Loxechinus albus (Molina)

Plate 43, Fig. 19

Echinus albus Molina, 1782, p. 200.

Loxechinus albus Desor, 1858, p. 136.

Strongylocentrotus albus H. L. Clark, 1910, p. 347, pl. 12, fig. 1.

This large sea-urchin of the western coast of South America is extensively used for food along the Chilean coast as *Tripneustes* is in the West Indies. In both cases it is the voluminous gonads which are eaten, commonly roasted in the "half-shell." The largest specimen taken by the *Velero* is somewhat less than 100 mm h. d. but specimens 120 mm in diameter are reported. Altogether only 23 specimens were taken. The smallest is 16 mm in diameter, the largest 84. The parasitic crab, (*Pinnaxoides*), which so often lives in the periproct of this sea-urchin and the following, *Caenocentrotus gibbosus*, is evidently present in at least 9 cases. The color is pretty uniformly green in spite of being often more or less bronzed over with red-brown. In specimens less than 20 mm h. d. the tips of the spines may be quite red. But in none of the specimens that I have ever seen is there any obvious reason why the specific name *albus* should have been attached to this sea-urchin.

Distribution.—The *Velero* met with this urchin only three times—first in 1935 along the shore in Independencia Bay, again in 1938 in San Juan Bay and Independencia Bay, and thirdly, a few days later further north, among the Lobos de Afuera Islands. This extends the range from the Lobos de Afuera Islands, northern Peru ($6^{\circ} 53' 50''$), southward to the Straits of Magellan.

Type.—Unknown.

Type locality.—Chile.

Depth.—Shore to 40 fms.

Specimens examined.—23 specimens from 6 stations.

Caenocentrotus gibbosus (L. Agassiz and Desor)

Plate 43, Fig. 20

Echinus (Toxopneustes) gibbosus L. Agassiz and Desor, 1846, p. 367.

Caenocentrotus gibbosus H. L. Clark, 1912, p. 348.

Grant and Hertlein, 1938, p. 29, pl. 10, figs. 3, 4.

Mortensen, 1943, p. 321, pl. 34, figs. 3, 4; pl.

63, figs. 7, 8, 11, 13, 19.

This is another South American urchin which has not followed the coast north of the equator but unlike the preceding species it has followed

PLATE 47

- Fig. 27. *Clypeaster ochrus* H. L. Clark, aboral view, $\times \frac{2}{3}$, p. 297
Fig. 28. *Clypeaster rotundus* (A. Agassiz), aboral view, $\times \frac{2}{3}$, p. 296

PLATE 48

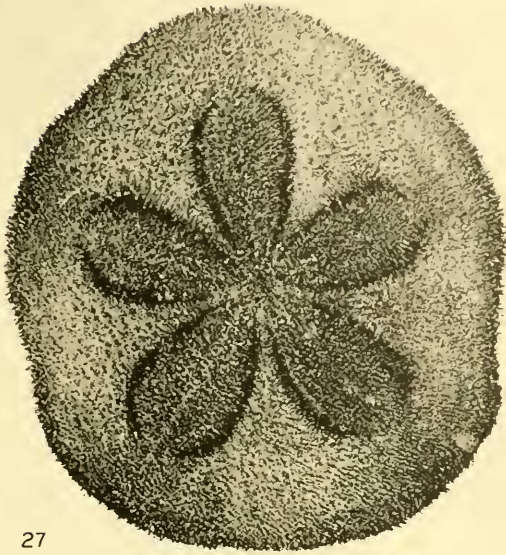
- Fig. 29. *Clypeaster speciosus* (Verrill), aboral view, $\times \frac{2}{3}$, p. 308
Fig. 30. *Clypeaster elongatus*, new species, aboral view, $\times \frac{2}{3}$, p. 308

PLATE 49

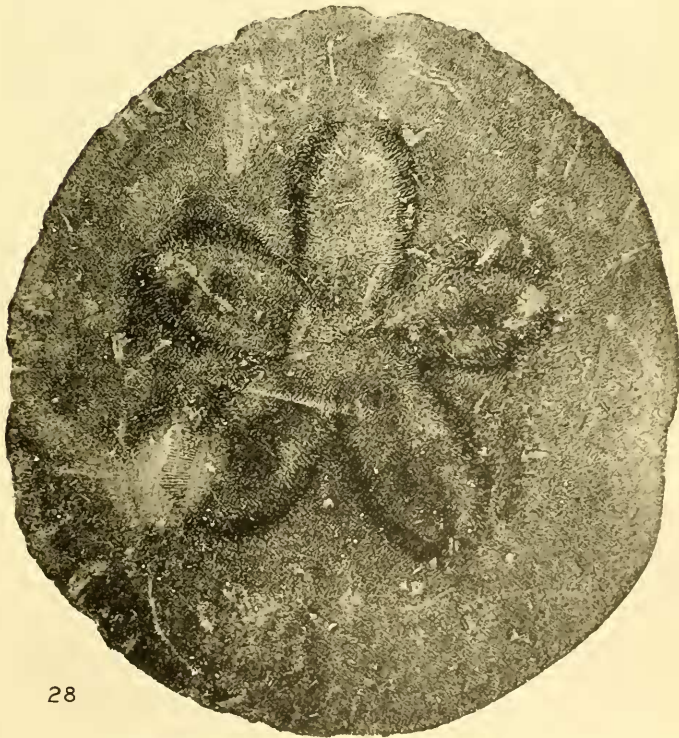
- Fig. 31. *Clypeaster elongatus*, new species, oral view, $\times \frac{2}{3}$, p. 308
Fig. 32. *Dendraster excentricus* Eschscholtz, aboral view, $\times \frac{4}{5}$, p. 310

PLATE 50

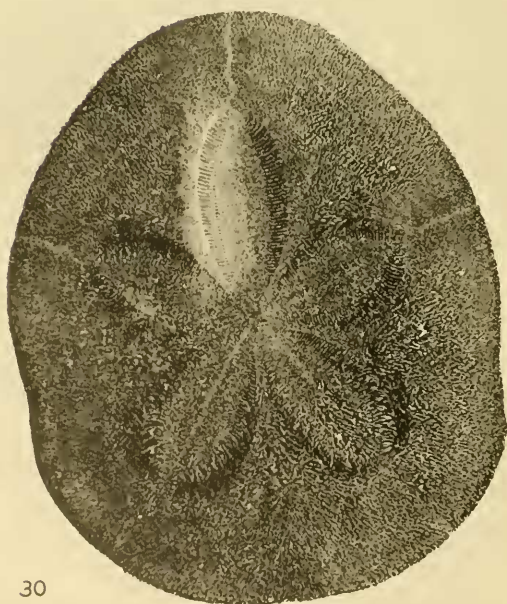
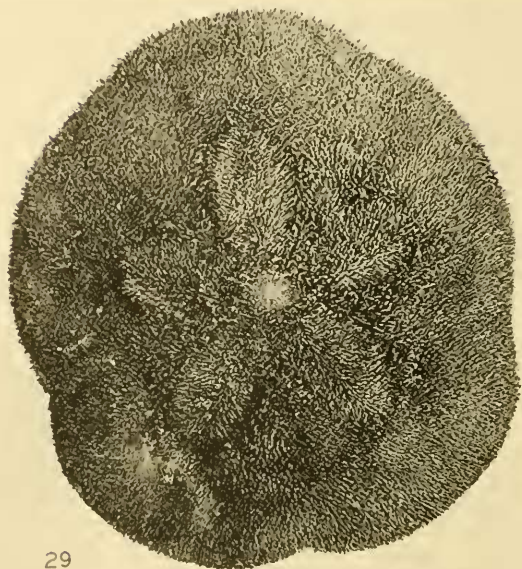
- Fig. 33. *Clypeaster elongatus*, new species, lateral view, $\times \frac{2}{3}$, p. 308
Fig. 34. *Dendraster laevis*, new species, aboral view, $\times \frac{2}{3}$, p. 312
Fig. 35. *Dendraster laevis*, new species, oral view, $\times \frac{2}{3}$
Fig. 36. *Dendraster laevis*, new species, aboral view, smooth surface, $\times \frac{2}{3}$

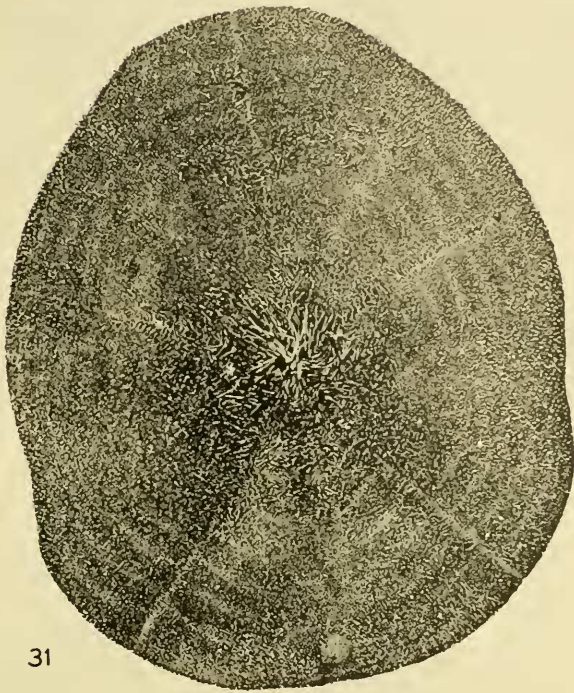


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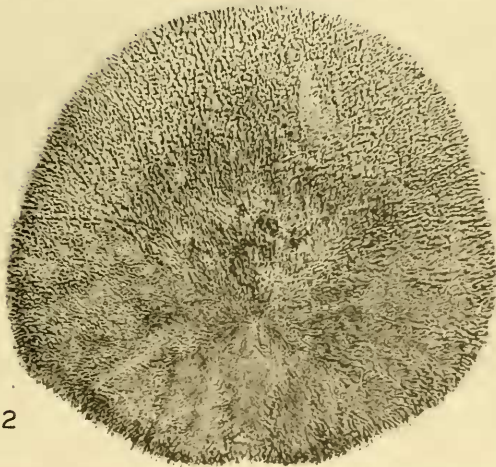


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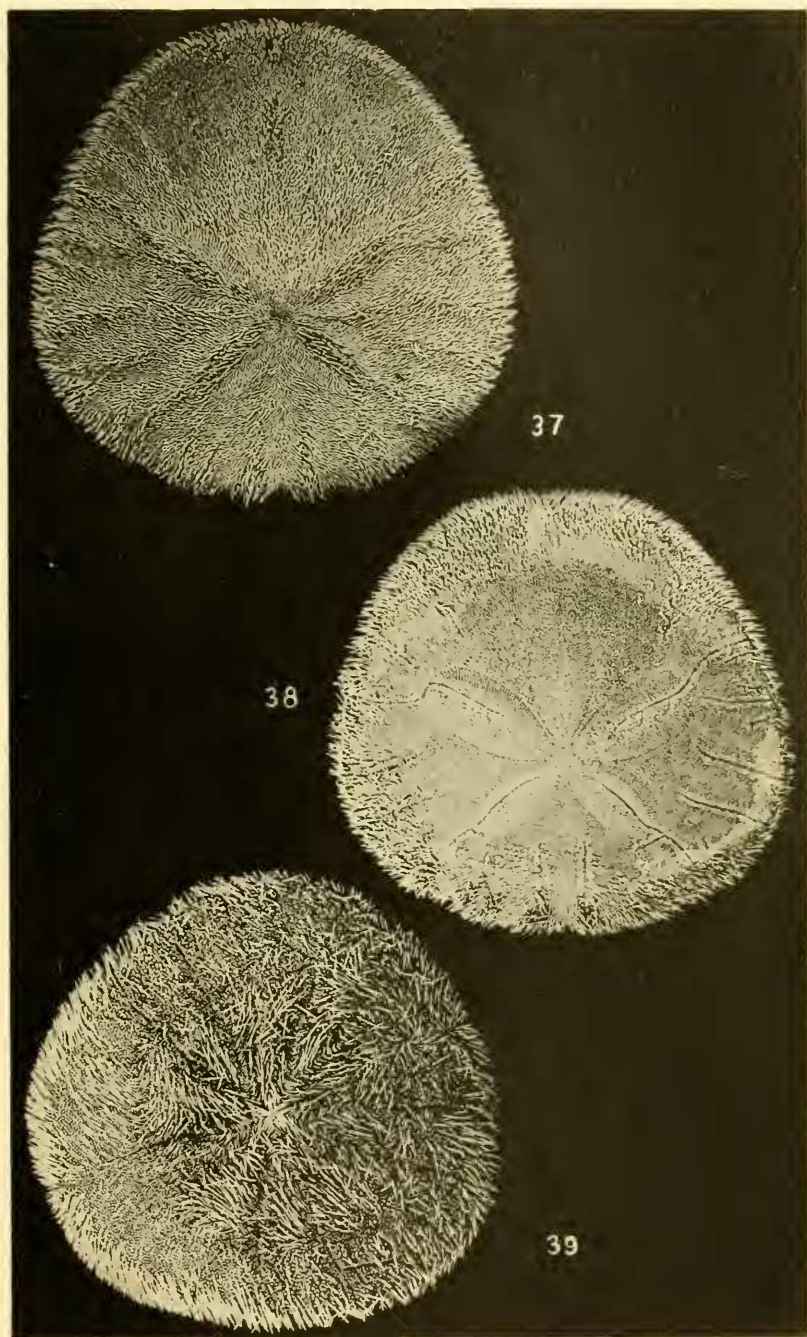
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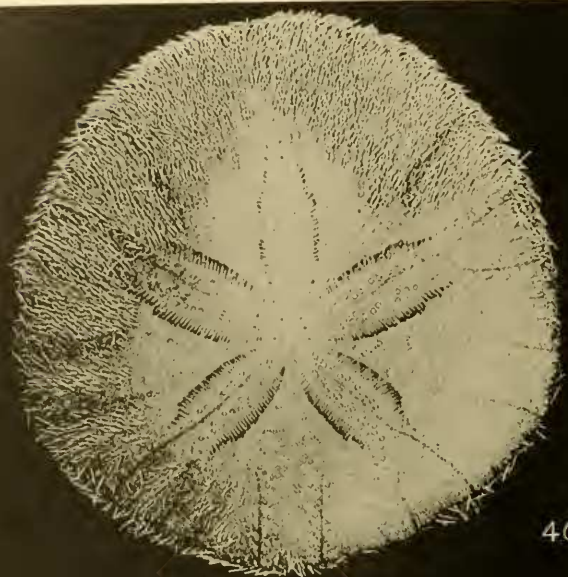


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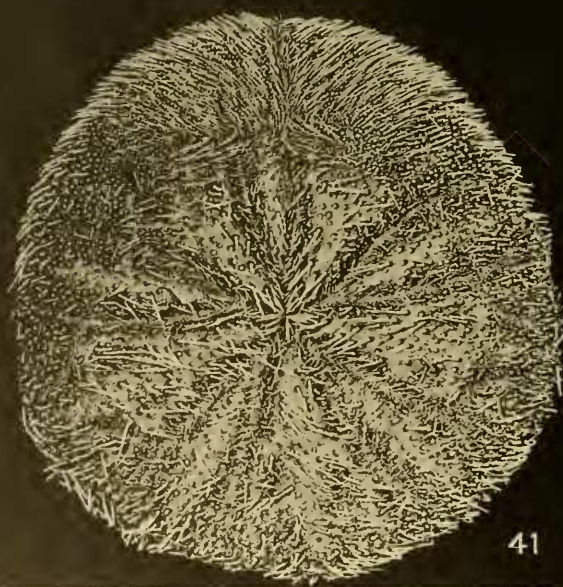


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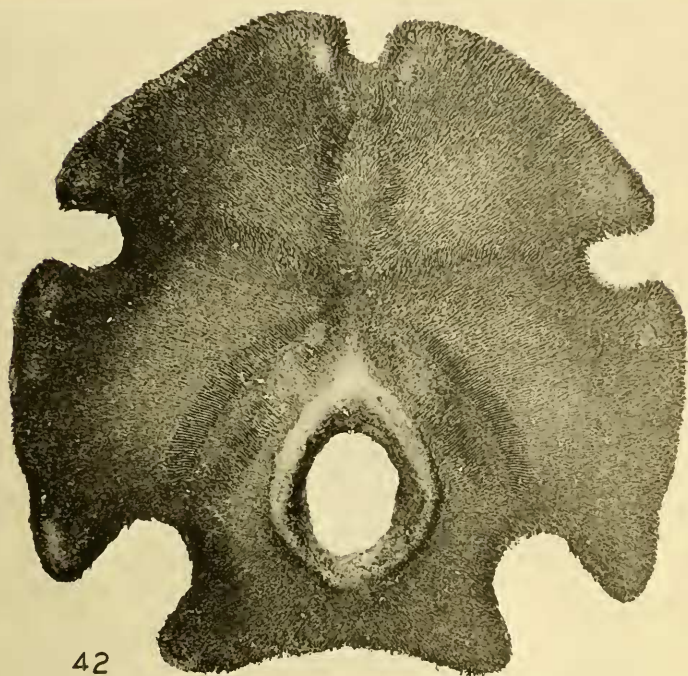




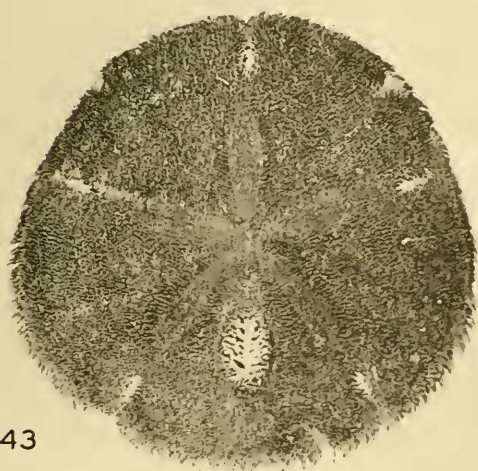
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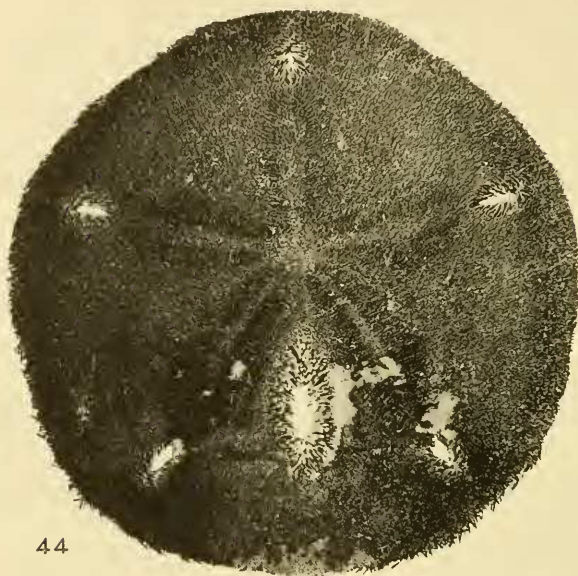
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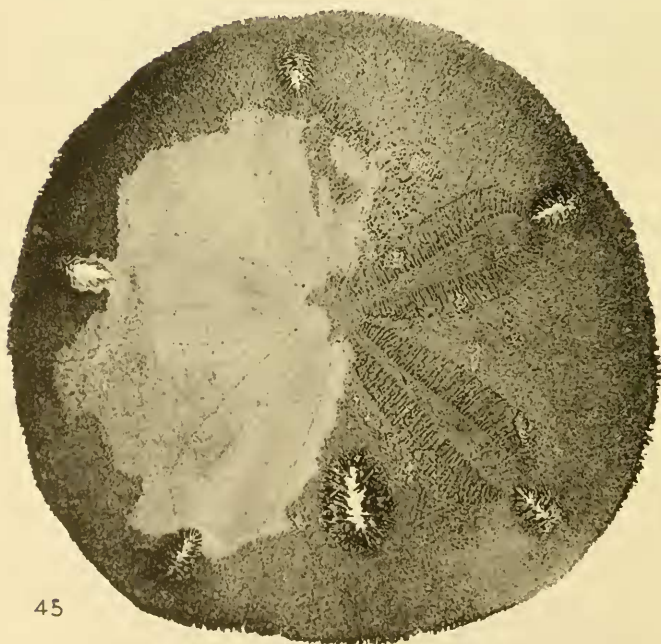
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PLATE 51

- Fig. 37. *Dendraster mexicanus*, new species, aboral view, rough surface, x1, p. 313
Fig. 38. *Dendraster mexicanus*, new species, aboral view, smooth surface, x1
Fig. 39. *Dendraster mexicanus*, new species, oral view, x1

PLATE 52

- Fig. 40. *Dendraster rugosus*, new species, aboral view, $x\frac{4}{5}$, p. 318
Fig. 41. *Dendraster rugosus*, new species, oral view, $x\frac{4}{3}$

PLATE 53

- Fig. 42. *Encope grandis* L. Agassiz, aboral view, $x\frac{4}{5}$, p. 325
Fig. 43. *Encope perspectiva* L. Agassiz, aboral view, x1, p. 326

PLATE 54

- Fig. 44. *Encope wetmorei* A. H. Clark, aboral view, $x\frac{2}{3}$, p. 326
Fig. 45. *Encope laevis*, new species, aboral view, $x\frac{2}{3}$, p. 327

the equator to the Galapagos Islands. Just how it reached the islands cannot be said but judging from the material at hand conditions are not as favorable for it there, as the Peruvian specimens are conspicuously larger and more robust than those from the islands. Of the 82 specimens in the *Velero* collection, 69 are from the Lobos de Afuera Islands, Peru. They range from 30-68 mm in diameter. The tests are usually brown with the spines a deep bronze-green, their tips more or less reddish, but some individuals are distinctly greenish rather than brown. All are more or less deformed at the abactinal system by the presence of the parasitic crab, *Pinnaxoides*. Of the remaining 13 specimens, 2 small individuals are from the northernmost station known for *Caenocentrotus*, the shore of La Plata Isle, Ecuador. They are about 25 mm h. d. and have notably long primary spines. Both are infested with the parasitic crab. Another pair are from Fronton Island, near Callao, Peru, one a mere fragment, the other a good adult, like those from Lobos de Afuera. The other 9 specimens are from the Galapagos Islands, 6 from the reef north of Tagus Cove, Albe-marle Island, one from Tagus Cove, one from Academy Bay, Indefatigable Island, and one from Sullivan Bay, James Island. They range from 24 to 41 mm in diameter, the primary spines are relatively stout, and apparently none are infested with the crab, *Pinnaxoides*. It should be added, however, that other specimens of *Caenocentrotus* from the Galapagos have shown the presence of the crab. Except for the smaller size and shorter spines, the Galapagos *Caenocentrotus* is very similar to the Peruvian.

Distribution.—Guayaquil, Ecuador to northern Chile; Galapagos Islands.

Type.—Paris Museum.

Type locality.—Galapagos Islands.

Depth.—Littoral.

Specimens examined.—82 specimens from 8 stations.

Allocentrotus fragilis (Jackson)

Plate 44, Fig. 21

Strongylocentrotus fragilis R. T. Jackson, 1912, p. 128.

H. L. Clark, 1912, p. 354, pl. 113, figs. 3-6.

Allocentrotus fragilis Mortensen, 1942, p. 232.

Mortensen, 1943a, pp. 254-255, pl. 30, figs. 10-17.

If a sea-urchin could ever be called a "beautiful" creature, there is no doubt that this species would be a first choice for the title. The delicacy of its test and spines is remarkable and the beauty of their coloring is indis-

putable. Although large and strikingly colored, no specimens seem to have been collected until well into the twentieth century. It is probable that specimens secured accidentally by dredge or trawl were so badly damaged that they were not brought ashore, and the few that escaped that fate were not attractive enough to lead anyone, not a specialist in sea-urchins, to give them any attention. The urchin is so common in the limited area it inhabits that the *Velero* has brought in altogether 240 specimens from 59 stations, ranging in horizontal diameter from 2 mm to just over 100. The height of the low test is usually less than half its diameter, a specimen 80 mm h. d. having a height of about 35 mm. Young individuals are quite flat, a specimen 30 mm across being only 11 mm high. The test is remarkably fragile, only a millimeter thick in a well-grown adult. As a rule the colors are light and often bright. A normal specimen has the test rose red or pink with a more or less violet cast on the upper side, becoming more and more violet orally. The small spines are much the same color but the larger ones are orange or vermilion at base becoming very light, almost white on the distal part. The conspicuous pedicellariae are nearly white. Occasional specimens are much darker, with test dusky purple and dull orange, and the spines dull gray or violet or even brown. When freshly caught or well preserved, either in alcohol or dry, the slender, delicate spines varied, more or less bright colors compel admiration.

Distribution.—The *Velero* has taken this fine sea-urchin at 59 stations in depths of 39-380 fms off the coast of southern California. The material collected by the *Albatross* on which the species was based, was taken between northern Washington ($47^{\circ} 46' N$) and the Mexican boundary ($32^{\circ} 32' 30''$) in depths of 48 to 417 fms. The *Velero* took no specimens at any station north of $34^{\circ} 06' 30''$ or south of $32^{\circ} 34' 50''$, in depths of 40 to 380 fms, except one half grown specimen labeled as from Station 1246-41, which is off Cedros Island, Lower California, in 81-83 fms. (There is no good reason for doubting the label with this specimen but it is odd that no other specimens of *fragilis* have been taken in waters south of the United States.) It may properly be considered a definitely North American sea-urchin. According to other authors the range is from Vancouver Island to Lower California.

Type.—R. T. Jackson Collection No. 838.

Depth.—39-640 fms.

Type locality.—Catalina Island.

Specimens examined.—240 specimens from 59 stations.

Strongylocentrotus franciscanus (A. Agassiz)

Plate 45, Fig. 23

Toxocidaris franciscana A. Agassiz, 1863, p. 22.*Strongylocentrotus franciscanus* A. Agassiz, 1872a, p. 163.

Mortensen, 1943a, p. 242, pl. 28, figs. 1-7; pl. 29, figs. 1-4.

There are in the *Velero* collection 343 specimens of *Strongylocentrotus* from 24 stations which are here referred to this conspicuous sea-urchin. In point of size it rivals *Triploneustes*. The latter reaches perhaps a greater diameter of the test, 150 mm as against 146 for the present species but the latter has such long, heavy spines, 50 mm or even more in some individuals, it is evidently the largest of the west coast Echini. Young individuals with a test diameter of 10-15 mm have the relatively slender spines about two-thirds as much, while adults with a diameter of 100 mm or more are satisfied with spines only a third of that. In two specimens at hand from Point Vicente, California, which are rather more than 100 mm in diameter the number of coronal plates (and hence the number of primary spines) is considerably more than normal and the length of the primaries is markedly less, only 20-30 mm. The appearance of these specimens is thus strikingly different from normal specimens but the differences are probably associated with some unusual feature of their habitat, such as excessively strong surf or tidal currents. Further collecting at Point Vicente and study of local conditions might explain this curious anomaly.

The color of normal *franciscanus* when young is a light fawn brown but with growth the color darkens and in most individuals it becomes a very deep purple or even almost black. Curiously enough many individuals instead of becoming very dark remain light colored until half grown and are then a dull and pale "old rose" or pale violet. With increased age and size the dark color becomes predominant and the big adults are nearly if not quite black. Other individuals never become black at all but even when full-grown are light-colored, a peculiar shade of brown, lightest at the base of the spines, darkest near the tips. Curiously enough such specimens if placed in a dilute solution of formalin (4 per cent) to which a pinch of corrosive sublimate has been added turn bright green, strikingly different from any normal shade of the living urchins. On being dried, the green disappears more or less and the urchin becomes brown once more but darker, especially on the distal portion of the spines. It is conceivable that the colors are an indication or a sex dimorphism and an investigation into the matter of a possible correlation of color and sex might prove rewarding.

Another remarkable thing affecting the color is undeniable hybridization of *franciscanus* and *purpuratus*. The hybrids when young have the primaries quite purple or bright violet and shades of these colors persist as the animal grows. The hybrids are distinguishable from *purpuratus* by the smaller number and much greater size of the primary spines, while their unusual color distinguishes them from *franciscanus*. Of course, many specimens are so nearly intermediate, their identification becomes a matter of opinion. A careful study of this hybridization would surely be rewarding.

Distribution.—There is no doubt that *franciscanus* is characteristic of the coastal region of the western United States and Canada, and Mortensen reports its occurrence on the Alaskan coast and even in northern Japan. How far south on the American coast its range extends is still somewhat uncertain. Mortensen says Cedros Island, Lower California, is the southern limit and two small specimens in the *Velero* collection from that island and two from Thurloe Bay, near the island, confirm that opinion. There is, however, in the present collection a very good adult specimen from "shore collecting at Petatlan Bay, Mexico," Lat. $17^{\circ} 31' 45''$, but this seems quite improbable and needs confirmation. In the vicinity of Newport and Balboa, California, *franciscanus* is common and grows to a large size, but the largest specimens in the *Velero* collection are from shore collecting between Cape Arago State Park and Yaquina Head Light on the Oregon coast.

Type.—M.C.Z. no. 1686 (Cotype).

Type locality.—San Francisco, California.

Depth.—Shore to 50 fms.

Specimens examined.—343 specimens from 24 stations.

***Strongylocentrotus purpuratus* (Stimpson)**

Plate 44, Fig. 22

Echinus purpuratus Stimpson, 1857, p. 86; 1857a, p. 526.

Strongylocentrotus purpuratus A. Agassiz, 1872a, p. 165.

Mortensen, 1943a, p. 236, pl. 26, figs. 1-8.

Like *franciscanus*, this species is characteristic of the western coast of North America. It is even more common, the present collection containing over 500 specimens. They show a diversity in spinulation which is more extraordinary than anything shown by any other American sea-urchin. The normal condition is the presence of a double series of primary spines in each ambulacrum and interambulacrum; these spines are about 10 mm long, rather stout and quite acute. Each ambulacral plate carries an additional primary spine, not so large at each end of the plate. Each inter-

ambulacral plate carries a similar but slightly larger spine at each end. Miliary spines are fairly numerous among these primary and secondary spines so the test is normally very completely but not densely covered. The abactinal system of plates is similarly well covered but the peristome is quite free from spines. Many, perhaps most adult specimens differ from this typical spinulation in one of two ways. On the one hand the primary spines are disproportionately bigger, 15 mm or more in length and more than a millimeter thick basally. In extreme cases the primaries are over 20 mm long and 2 mm thick at base. On the other hand, the primary spines increase markedly in number but decrease in thickness and length; they are 6 or 7 mm long and scarcely more than half a millimeter in thickness. This diminution of the primaries occurs for the most part above the ambitus and may continue to such an extent that there are no normal primaries on the upper half of the test, but the whole abactinal surface is covered by a fairly dense coat of small secondary and miliary spines. Whether this condition is due to some feature of the environment such as constant heavy surf or to a diseased condition resulting from parasites or some deficiency of the environment, we do not know, but the result is a sea-urchin whose identity would be difficult to determine without a good series of connecting links.

Aside from environmental conditions modifying structure and appearance, there is no doubt that hybridization with *franciscanus* is a frequent if not a constant factor in the life history of *purpuratus*. As the two species often occupy the same regions and even the same environmental areas, it is not strange that cross fertilization often occurs and as a result many individuals are found whose correct identification is too much for even an experienced taxonomist. Color is the most useful factor in determining the species for typical *purpuratus*; it is at first green and then becomes purple and when large enough to be called adult it is practically entirely purple as the name indicates. The larger species, *franciscanus*, is never purple nor does it have any trace of such purple as characterizes *purpuratus*. Young individuals are light brown, almost or quite a fawn brown, and usually this becomes increasingly dark, until very large adults are a very dark violet brown, sometimes almost if not quite black. But there is never any indication of the purple of *purpuratus*. Hybrids usually show some indication of purple on the primary spines. A second indication of hybridization is seen in the stoutness of the primary spines. While very large individuals of *purpuratus* may have unusually large primary spines they are never equal to the normal spines of *franciscanus*. Oftentimes specimens occur which have the general form and appearance of *purpuratus* but the

primaries are disproportionately stout yet have a purplish tint. Such individuals are probable hybrids. A critical study, in a marine laboratory, of cross fertilization between the two species would yield interesting, perhaps important results.

Distribution.—The range of *purpuratus* is given by Mortensen as from Cedros Island, Lower California to Vancouver Island, with a dubious southern limit at La Paz and an equally dubious northern limit at Sitka. He considers it strictly littoral with 20 meters apparently as the bathymetric limit. The *Velero* has secured specimens at 46 stations, of which the northernmost was at Boiler Bay, Oregon, the southernmost at Petatlan Bay, Mexico, Lat. $17^{\circ} 32' N$. As the only other stations south of the United States at which *purpuratus* was secured are at or near Cedros Island, the Petatlan Bay record needs confirmation. Neither the *Albatross* nor the Templeton-Crocker Expedition took *purpuratus* in the Gulf of California, or near La Paz. The specimens labeled Petatlan are undoubtedly *purpuratus* but, as in the case of *franciscanus*, the locality is hard to credit. As for the bathymetrical range of the species, there can be no doubt that it is greater than supposed for the *Velero* took it at several stations in water ranging from 15 to 88 fms. These were young individuals, however, and it is probable the normal habitat of the species is above 15 fms.

Type.—U.S.N.M. No. 2495.

Type locality.—San Francisco, California.

Depth.—Littoral to 88 fms.

Specimens examined.—498 specimens from 46 stations.

Family **Echinometridae**
Echinometra oblonga (Blainville)

Plate 45, Fig. 24

Echinus oblongus Blainville, 1825, p. 95.

Echinometra oblonga Blainville, 1834, p. 225.

Echinometra mathaei oblonga Mortensen, 1943a, p. 393, pl. 48, figs. 1-20.

The status of this species or form of *Echinometra* is so perplexing that no two writers seem to have just the same opinion on the matter. Mortensen's treatment of the problem is entitled to the greatest respect, for his wide experience, extraordinary industry and unusual skill in wrestling with such a situation are beyond compare. The only reason for not accepting his conclusion outright is that *mathaei* does not occur in the Eastern Pacific whereas *oblonga* does, and there it intergrades with *VanBrunti* in a perplexing way. The *Velero* collection contains *Echinometras* which seem to be *oblonga* in its most typical form, high, elongated, well-rounded

PLATE 55

Fig. 46. *Encope laevis*, new species, oral view, $\times\frac{2}{3}$, p. 327

Fig. 47. *Encope micropora* L. Agassiz, aboral view, $\times\frac{2}{3}$, p. 329

PLATE 56

Fig. 48. *Encope cocosi*, new species, aboral view, $\times\frac{2}{3}$, p. 330

Fig. 49. *Encope cocosi*, new species, oral view, $\times\frac{2}{3}$

PLATE 57

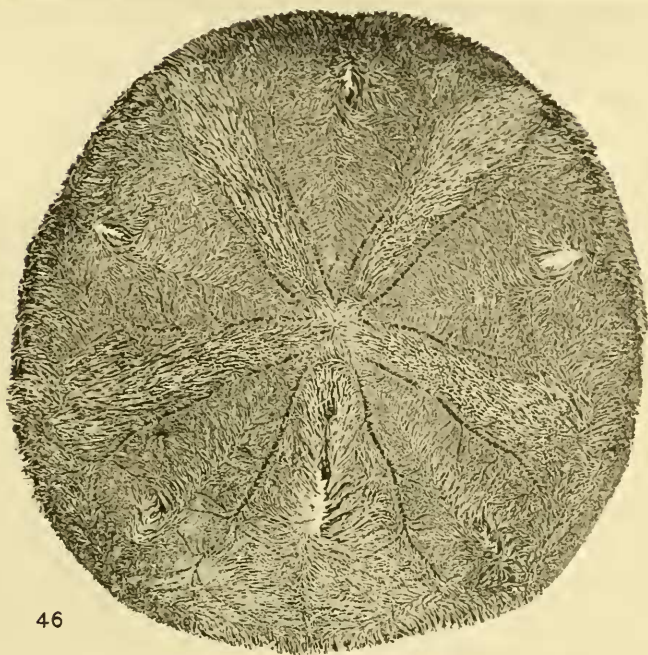
Fig. 50. *Encope galapagensis* A. H. Clark, aboral view, $\times\frac{2}{3}$, p. 331

Fig. 51. *Encope galapagensis* A. H. Clark, oral view, $\times\frac{2}{3}$

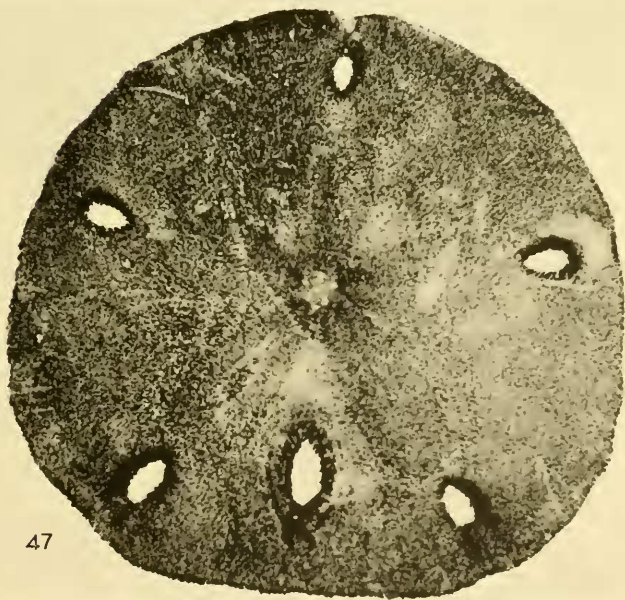
PLATE 58

Fig. 52. *Encope irregularis*, new species, aboral view, $\times\frac{2}{3}$, p. 332

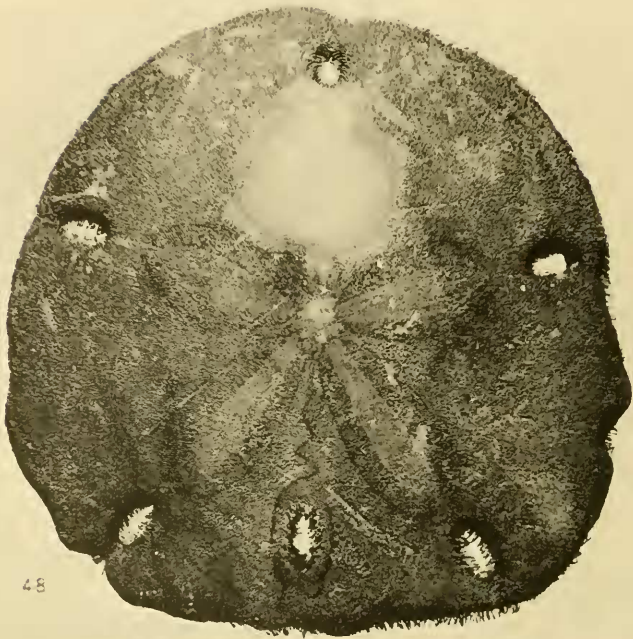
Fig. 53. *Encope irregularis*, new species, oral view, $\times\frac{2}{3}$



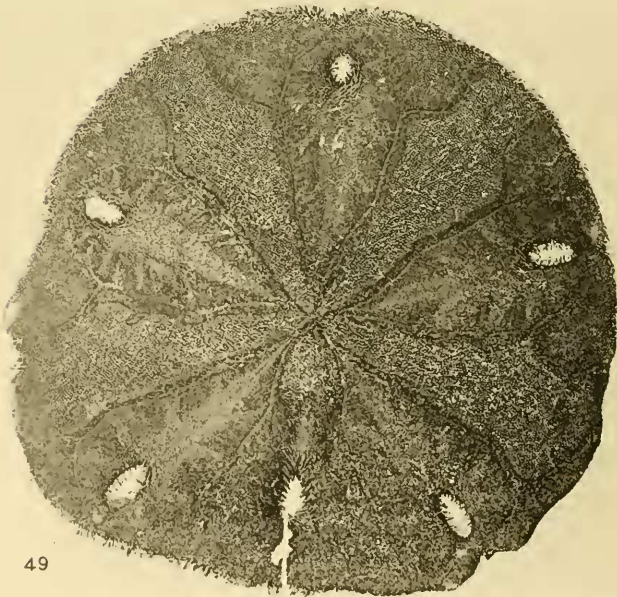
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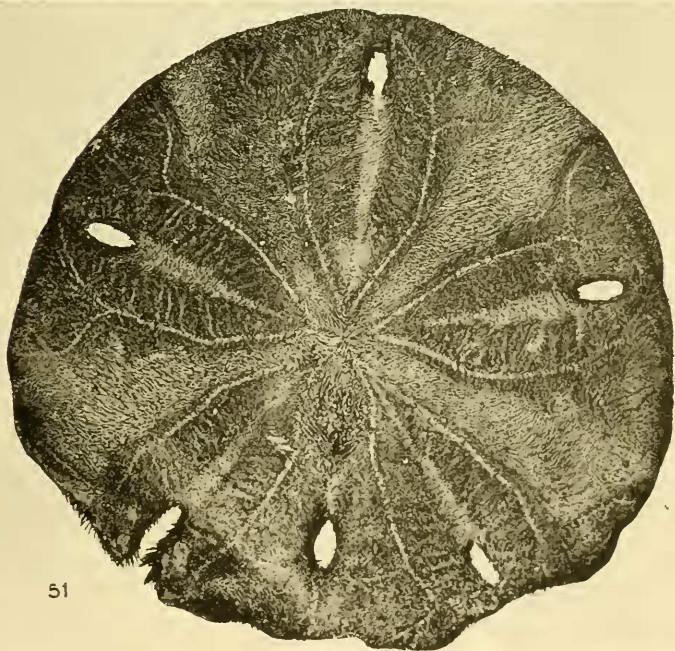
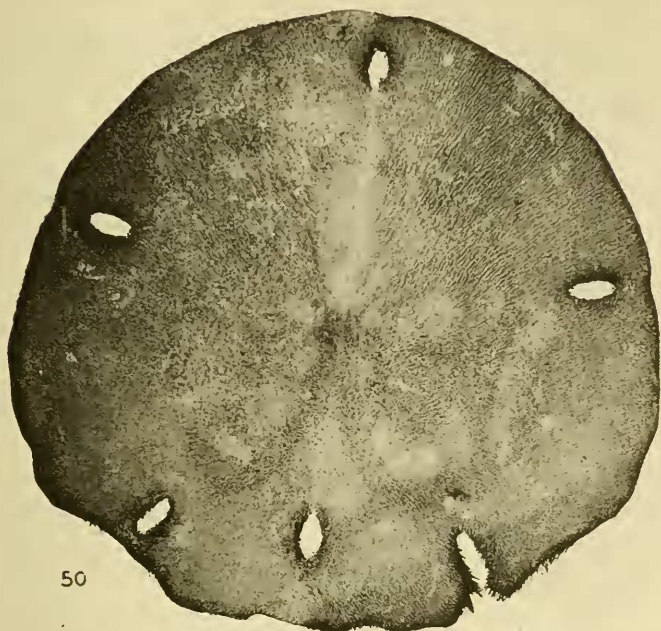
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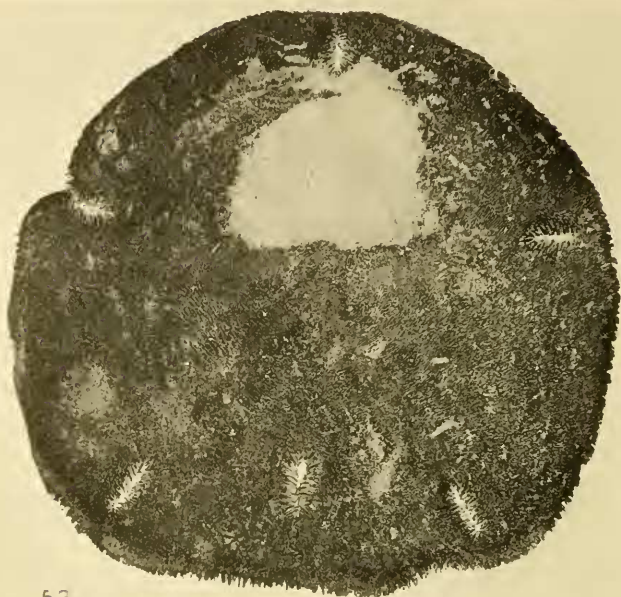


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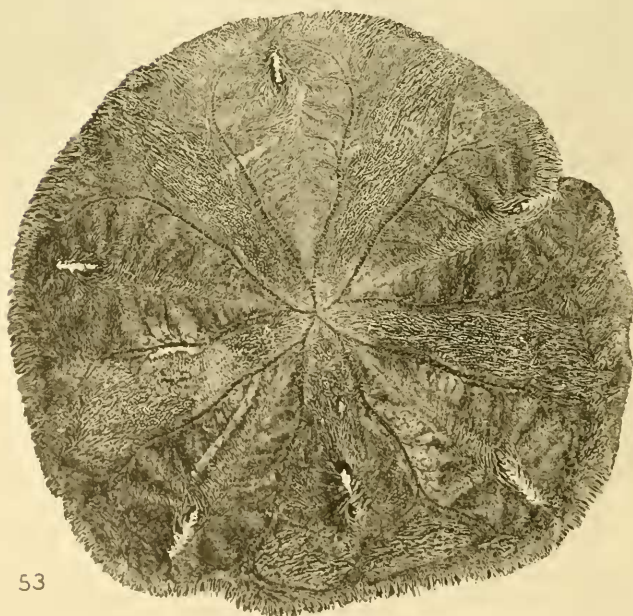


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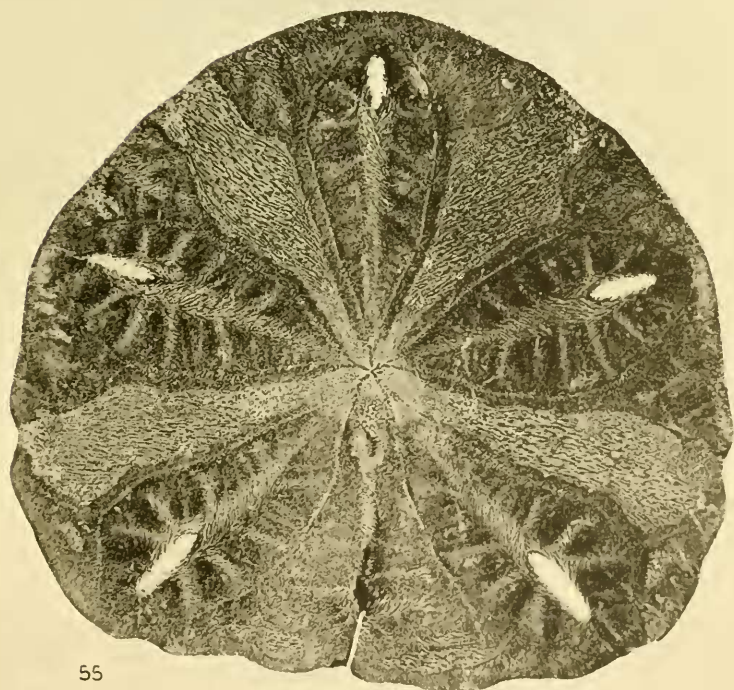
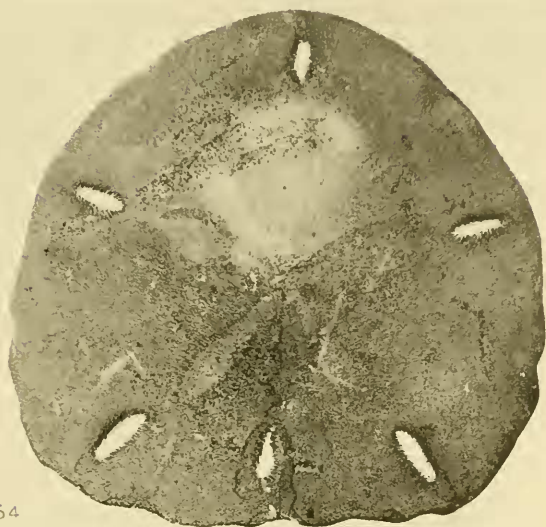


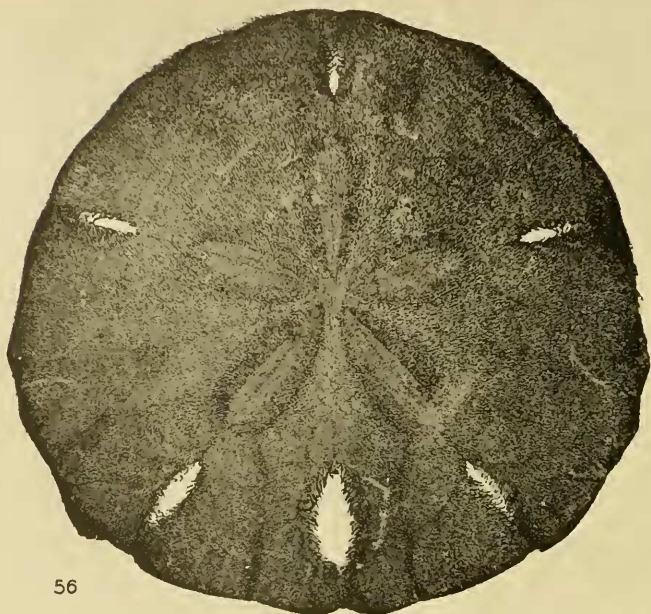


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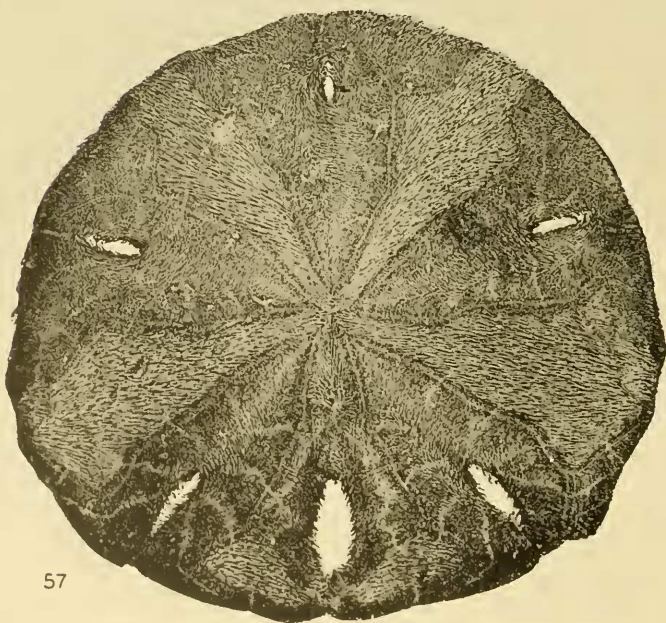


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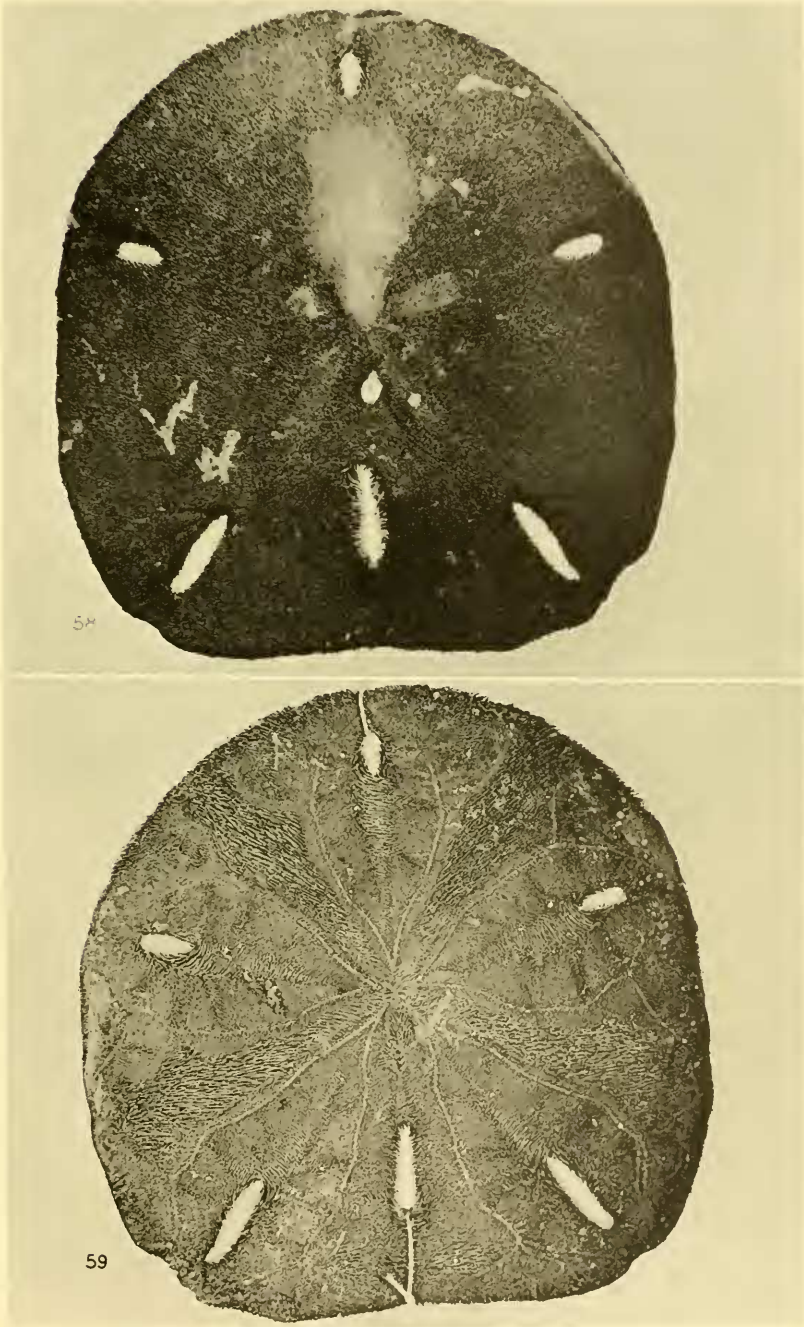




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PLATE 59

Fig. 54. *Encope ecuadorensis*, new species, aboral view, $\times\frac{1}{2}$, p. 333

Fig. 55. *Encope ecuadorensis*, new species, oral view, $\times\frac{2}{3}$

PLATE 60

Fig. 56. *Encope fragilis*, new species, aboral view, $\times\frac{2}{3}$, p. 335

Fig. 57. *Encope fragilis*, new species, oral view, $\times\frac{2}{3}$

PLATE 61

Fig. 58. *Encope insularis*, new species, aboral view, $\times\frac{1}{2}$, p. 336

Fig. 59. *Encope insularis*, new species, oral view, $\times\frac{1}{2}$

PLATE 62

Fig. 60. *Mellita longifissa* Michelin, aboral view, $\times 1$, p. 337

Fig. 61. *Cassidulus pacificus* A. Agassiz, aboral view, $\times 3$, p. 338

test with 4 or 5 rather large ambulacral pores in each arc, and short, stout, pointed primary spines of an almost black color. These spines tend to point upward or definitely forward or backward and give the impression that the urchins live in crevices or fissures in or between rocks. They do not bore holes (as *Echinostrephus* does) but it is possible that they enlarge crevices into which they fit themselves to some extent. Nearly all specimens have the primary spines pointing more or less forward or backward, parallel to the longer axis of the test. The largest specimen is 45 mm long (not including spines), 39 mm wide and 29 mm high. If the spines are included the corresponding measurements are roughly 80 x 55 x 40 mm. The color of all the *Velero* specimens is uniformly very dark but not black as one is inclined to think at first sight. It is rather a very deep purple, as dark in the very young specimens as in the adults. Specimens of the following species (*VanBrunti*) are often nearly as dark but the purple tinge is more evident especially on the oral side. In the shape of the test, this species is clearly more elongated and higher than the Panamic, and the pore-pairs are definitely fewer, only 4 or 5, as against 6 to 8. Hence there is no serious difficulty in identifying *oblonga* as it exists in the Eastern Pacific. The trouble comes in the Western Pacific where the ubiquitous *mathaei* occurs so abundantly that it is difficult to draw any definite line between some of its very dark forms and the similarly dark *oblonga*. I think it must be agreed that *oblonga* is a variety gradually differentiating into a quite distinct species and in the Eastern Pacific it has attained that distinction.

Distribution.—The *Velero* has found *oblonga* common at Sulphur Bay, Clarion Island, and at Braithwaite Bay, Socorro Island. A fair-sized adult was taken along shore at Bindloe Island, in the northern Galapagos Islands. Along the western side of South Seymour Island, 7 very young but quite typical *oblonga* were collected and at Cartago Bay, Albemarle Island, an adult specimen was found. But not a single specimen has been secured at Cocos Island or along the Mexican or Costa Rican coast. The indications are that *oblonga* has come from the west and established itself firmly at Clarion Island. From there it has spread to its near neighbor Socorro, and from these two islands it is extending its range southward into the Galapagos Islands but is not yet common there and has apparently reached a southern limit at Albemarle Island.

Type.—Unknown.

Type locality.—Unknown.

Depth.—Shore and very shallow water.

Specimens examined.—85 specimens from 12 stations.

Echinometra VanBrunti A. Agassiz

Plate 46, Fig. 25

Echinometra VanBrunti A. Agassiz, 1863, p. 21.*Heliocidaris stenopora* H. L. Clark, 1912, p. 351, pl. 95, figs. 18-22; pl. 104, figs. 1-3; pl. 110, figs. 4, 5.*Echinometra VanBrunti* Mortensen, 1943a, p. 373, pl. 45, figs. 1-3.

This is apparently the commonest littoral sea-urchin of the tropical Eastern Pacific. The *Velero* collection contains 658 specimens taken at 92 stations. They range in size from young ones, nearly or quite circular, 5 to 10 mm in diameter, to large adults with a long axis exceeding 70 mm. Normal large adults have the lesser diameter nine-tenths of the longer, and the height is very generally about one-half the length. But there is considerable diversity and individuals having the normally lesser axis nearly or quite equalling the longitudinal axis are not very rare. There seems to be no doubt that *Heliocidaris stenopora* H. L. Clark is based on a large *Echinometra Van Brunti* as A. H. Clark, Ziesenhenné and Mortensen have recently pointed out. In the *Velero* collection there are some specimens in which the ambitus is nearly circular but they are commonly less than 40 mm in diameter and not one would be identified as *stenopora*, as the tuberculation of the test is not coarse enough and the primary spines are not sufficiently stout. Mortensen inclines to recognize a variety *rupicola* although it occurs in the same areas as typical *VanBrunti* but the hundreds of specimens in the *Velero* collection do not, in my opinion, warrant the recognition of such a form.

It was hoped and rather expected that among the *Echinometras* in the present collection, there would be from the Galapagos and Socorro Islands, some specimens of *E. insularis* but not one typical example has been found. Some specimens from Costa Rica have only 5 pore-pairs in the ambulacra at the ambitus but they have 6 pairs abactinally and the general appearance and spinulation is like that of *VanBrunti* from the same region. Unfortunately there is but a single young individual from Clarion Island, and only two lots from Socorro. This series includes one very large adult and 32 small ones and they are typical *VanBrunti*. There are 78 specimens from some 20 stations in the Galapagos but none of them represent *insularis*, which justifies the suspicion that that supposed species is not really valid.

The color of *VanBrunti* is remarkably uniform although the shade shows no little diversity. The basic color may be designated as violet especially when seen from below. There is a tendency on the one hand

towards gray and on the other towards black. As a rule specimens from any one locality are much alike in color though large specimens may be darker than small ones. There is never any white nor any hint of green, but suggestions of a red violet are sometimes evident, and very young specimens (under 15 mm h. d.) may have a very definite red orange or a dull yellow tint around the peristome.

Distribution.—According to Mortensen, this sea-urchin occurs as far north as "off Central California," but the *Velero* has not found it north of the Mexican boundary. Indeed she has not taken it anywhere on the western side of Lower California, although she has found it at various points in the Gulf as far north as Guaymas and Angel de la Guardia Island. It is common on the Mexican and Costa Rican coasts and in Panamic waters. Further south it has been taken by the *Velero* at various points on the coasts of Colombia, Ecuador, and Peru as far south as the Lobos de Afuera Islands. At the Galapagos Islands, it is quite common, being taken at more than 20 stations though never in large numbers. Some typical specimens were secured at Cocos Island and one good series was collected at Braithwaite Bay on Socorro. A single young specimen was collected at Clarion Island, but the *Echinometras* of Clarion Island need further collecting and study.

Type.—M.C.Z. no. 1851 (Cotype).

Type locality.—Acapulco, Mexico.

Depth.—Shore to 29 fms.

Specimens examined.—658 specimens from 92 stations.

Order EXOCYCLOIDA

Family Clypeastridae

Clypeaster europacificus H. L. Clark

Plate 46, Fig. 26

Clypeaster europacificus H. L. Clark, 1914, p. 27, pls. 129, 130, 131, 136, fig. 1.

The 102 specimens of this fine *Clypeaster* taken by the *Velero* form a very complete series from the babies 16 x 15 mm to the full grown adults just exceeding 200 mm in length. The largest specimen is 202 mm long by 200 mm wide and 30 mm high; the test margin is about 6 mm thick. In most specimens the width of the test is not so great proportionately, a normal adult is 184 by 174 mm with the height 27 mm. The young are nearly or quite circular and many individuals continue so throughout life. Some, however, elongate appreciably; the longest of the present series have the width nine-tenths of the length. As a rule the height is about 15

per cent of the length but occasionally it is appreciably more, in extreme cases it may be 30 per cent. The general texture of the test is not very stout and hence injuries to the margin are rather frequent resulting in more or less conspicuous deformities. One specimen about 113 mm in length, with the width somewhat less, has the central portion of the petaloid area abruptly raised and flattened, resulting in a curious hat-shaped form as seen from the side.

Color undergoes very considerable change with the growth. The youngest specimens are pale red violet, almost pink, above and cream color or nearly white below. With increasing size the color deepens. The upper surface becomes a deeper and more purple pink, violet, deep violet, brown violet, brown either yellowish or violet tinted, until in old specimens the very dark brown of the adult is reached. The ambulacral areas are often of a different shade so that the petals stand out more or less clearly. The cream-colored lower surface of the very young, becomes brownish yellow, yellow brown and ultimately a deep brown. In very old specimens there is a tendency for the ambulacral areas to darken and they may become more or less black at least along the midline. The dark shades of dried adults show considerable diversity, some specimens being quite gray. Young specimens, 25 mm or so in diameter may become deep violet above quite early, but occasionally remain light pink until sometime after that size is reached.

Distribution.—The original material on which the species was based came from the Gulf of California, Clarion Island, Hood Island in the Galapagos, and Panama. The *Velero* has extended that range very little, except to the south; the present collection contains a nice set of 12 small specimens, 25-70 mm long, from off La Plata Island, Ecuador, in 45-55 fms. In the Galapagos area only once was *europacificus* met with—a single specimen in Academy Bay, Indefatigable Island in 10-25 fms. It was not found at Clarion or Socorro Islands. From Panama, Costa Rica and Mexico a number of specimens were secured but the bulk of the material, more than 60 specimens, was taken in the Gulf of California, at various points up to Angel de la Guardia Island. The bathymetric range of this *Clypeaster* seems to be from 10 to 95 fms.

Type.—U.S.N.M. No. 34226.

Type locality.—Bay of Panama, 7° 57' N, 78° 55' W, 33 fms.

Depth.—10-95 fms.

Specimens examined.—102 specimens from 24 stations.

(Very likely this species is identical with Pfeffer's *Alexandria magnifica*. Th. Mortensen)

Clypeaster rotundus (A. Agassiz)

Plate 47, Fig. 28

Stolonoclypus rotundus A. Agassiz, 1863, p. 25.*Clypeaster rotundus* A. Agassiz, 1872a, p. 100.

H. L. Clark, 1914, p. 38, pls. 132, 133.

Although adult specimens of this *Clypeaster* are easily distinguished from the preceding, the young, before reaching a length of 25 mm are very difficult to determine. They are nearly or quite circular, or a little longer than wide, and very flat. The lower surface, at first nearly white becomes yellowish, and as a rule is soon yellowish-brown, as in *europacificus*. The subsequent color changes are similar in the two species but the body form is usually characteristic, for *europacificus* has the interr radial margins more or less evidently concave or at least straight, resulting in a pentagonal form with the length only a little, if at all, greater than the breadth. In *rotundus* the interr radial margins are more or less convex, and the outline may be nearly circular, but as a rule the length is somewhat greater than the width. The largest specimen in the present collection is 175 mm by 160; the height is 27 mm, but a second specimen with the same length and breadth is only 20 mm high. The most nearly circular adult at hand is 146 mm long by 137 mm wide, but a specimen 37 mm long is 36 mm wide.

Distribution.—There are 96 specimens in the *Velero* collection from 35 stations, well scattered along the coast from Santa Elena Bay, Ecuador to Georgia Island at the upper end of the Gulf of California. There are no records from the western coast of Lower California nor from anywhere above the Mexican boundary. There are 9 specimens from Clarion Island but none from Socorro. From Cocos Island there are two small specimens, dredged in relatively deep water, 30-50 fms. There are 20 specimens from 9 stations in the Galapagos Islands, but chiefly from Tagus Cove, Albe-marle Island. Some were taken in shallow water along shore but they were mostly dredged in 8-50 fms.

Type.—M.C.Z. no. 2188.

Type locality.—Acapulco, Mexico.

Depth.—Shore to 50 fms.

Specimens examined.—96 specimens from 35 stations.

Clypeaster ochrus H. L. Clark

Plate 47, Fig. 27

Clypeaster ochrus H. L. Clark, 1914, p. 30, pl. 141, figs. 1-3.

There can be no doubt of the close relationship between this species and *speciosus* but after a prolonged study of all the *Velero Clypeasters*, it seems best to maintain *ochrus* as at least an incipient species. Typical specimens in good condition are easily recognized, but immature or badly preserved individuals cause trouble. Moreover well-preserved specimens of the two species may be so much alike in color that it is very hard to determine to which species they belong but the greater height of the test with its somewhat greater concavity can usually be relied upon to distinguish *ochrus*; in *speciosus*, the height is about one-fifth of the length, in *ochrus* it is one-fourth. In the *Velero* collection, there are 47 *Clypeasters* which may be referred to *ochrus*. They range from 5 to 114 mm in length but the most typical is 104 x 96 mm with a height of 28 mm, the mouth is sunken 12 mm below the test margin. The characteristic color is a yellow brown with the petaloid areas and the lower surface dark brown in rather marked contrast, but most of the specimens from Cocos (Nuez) Island, Costa Rica, Panama and Ecuador are chocolate brown or purple brown of a more or less deep shade, rarely, however, as deep as in *speciosus*. One young specimen (48 x 44 mm) from James Island, Galapagos, in 10 fms is red purple, rather dull above but quite bright orally. The smallest specimen (5 mm), also from James Island, is a uniform light brown while the next largest (8 mm), from Ecuador, has the upper surface red violet.

Distribution.—The most typical specimens are from Ecuador, Colombia and the Secas Islands, Panama, but very good specimens are from Albemarle Island in the Galapagos. A large number of *Clypeasters* dredged at Nuez Island, off Cocos Island, in 31-50 fms are best referred to this species although the only adult from this locality is very dark colored. It has, however, the proportions and general appearance of *ochrus*. No specimens of *ochrus* were taken north of Costa Rica. Records from other authors extend the known distribution as far north as La Paz, Lower California.

Type.—M.C.Z. no. 4740.

Type locality.—Acapulco, Mexico.

Depth.—Shore to 50 fms.

Specimens examined.—47 specimens from 15 stations.

PLATE 63

- Fig. 62. *Agassizia scrobiculata* Valenciennes, aboral view, $\times \frac{2}{3}$, p. 339
Fig. 63. *Agassizia scrobiculata* Valenciennes, lateral view, $\times \frac{4}{3}$

PLATE 64

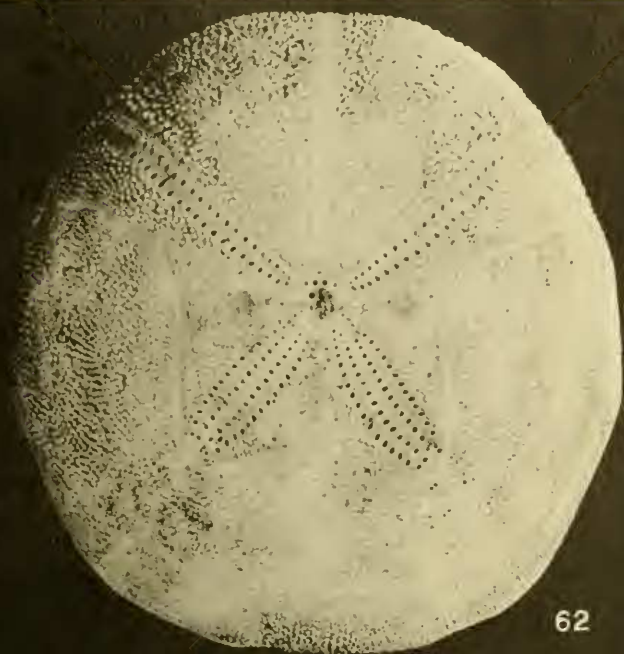
- Fig. 64. *Brisaster townsendi* (A. Agassiz), aboral view, $\times \frac{2}{3}$, p. 340
Fig. 65. *Moiria clotho* (Michelin), aboral view, $\times \frac{8}{3}$, p. 341

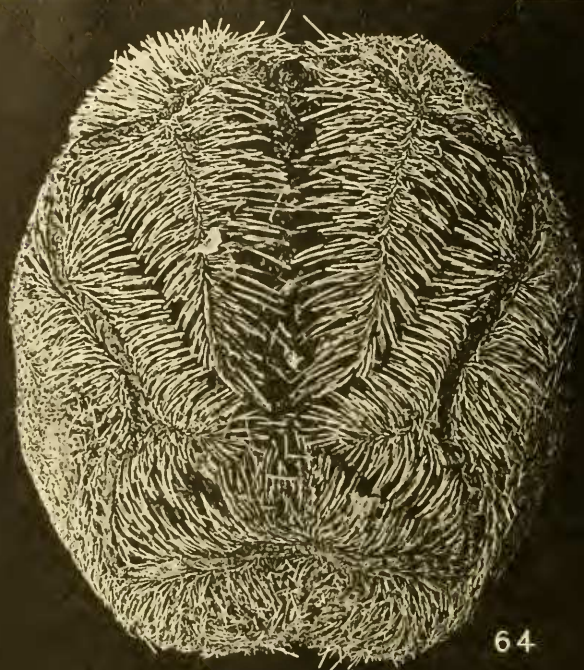
PLATE 65

- Fig. 66. *Brisopsis pacifica* (A. Agassiz), aboral view, $\times \frac{4}{3}$, p. 341
Fig. 67. *Brisopsis pacifica* (A. Agassiz), oral view, $\times \frac{4}{3}$

PLATE 66

- Fig. 68. *Plagiobrissus pacificus* H. L. Clark, aboral view, $\times 1$, p. 342
Fig. 69. *Plagiobrissus pacificus* H. L. Clark, oral view, $\times 1$
Fig. 70. *Plagiobrissus pacificus* H. L. Clark, lateral view, $\times 1$

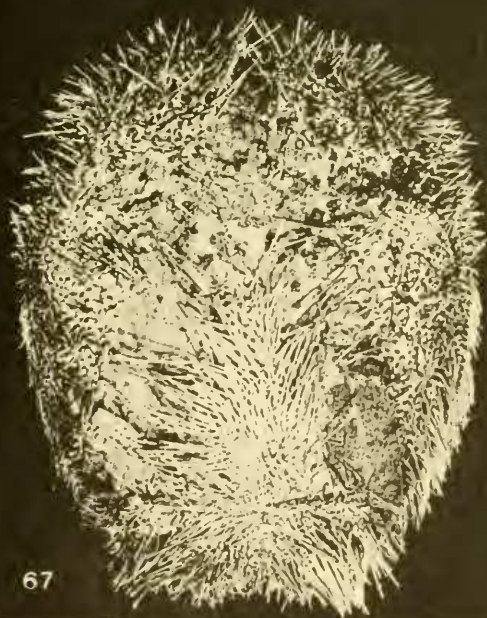
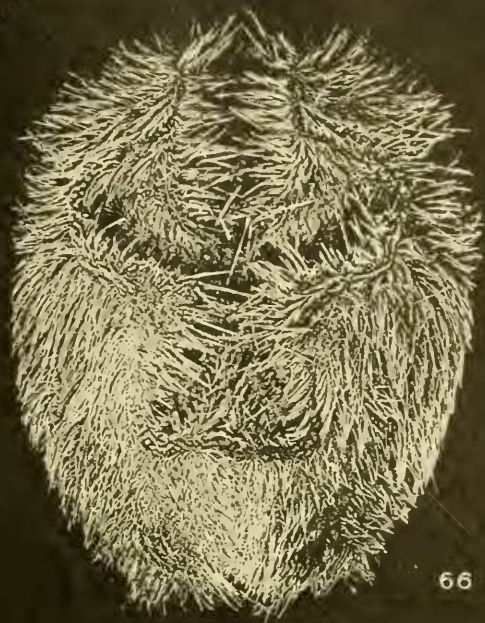


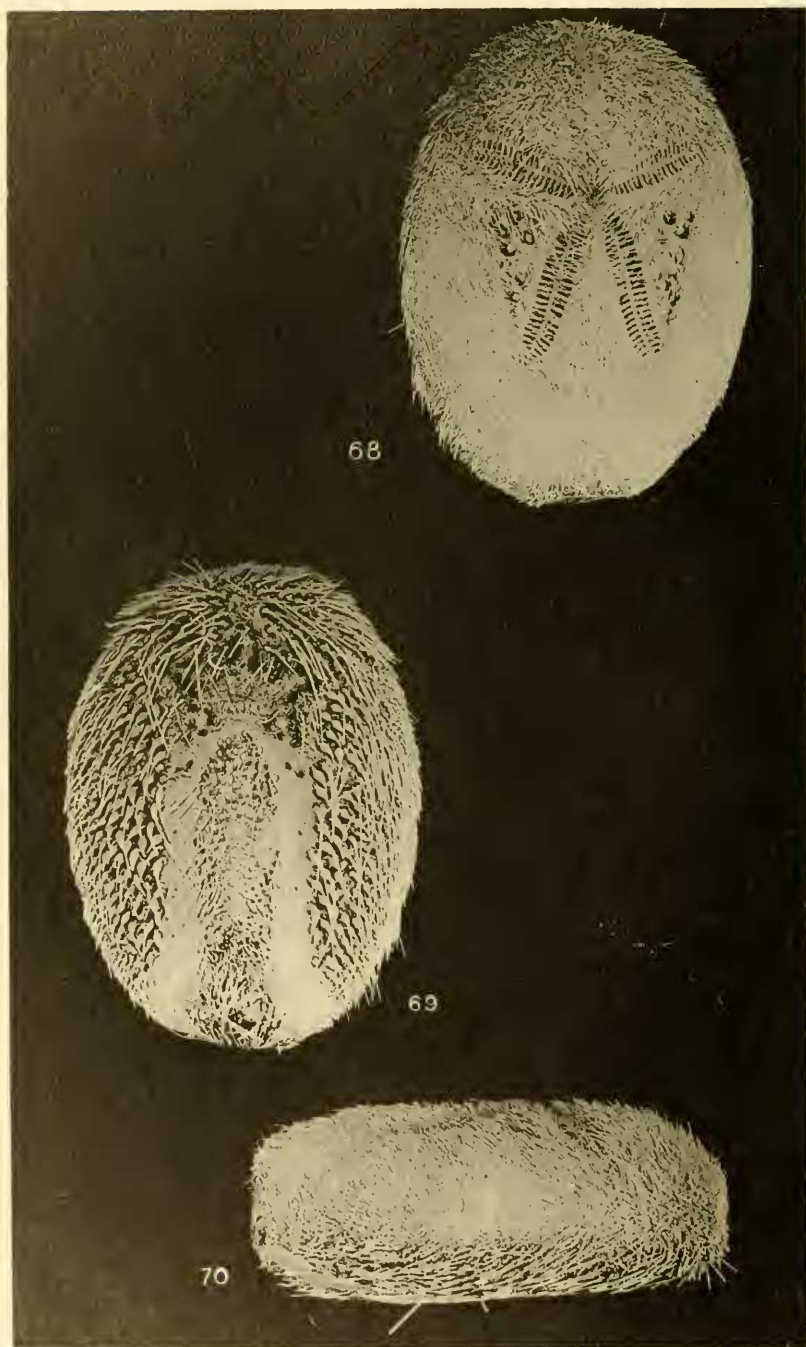


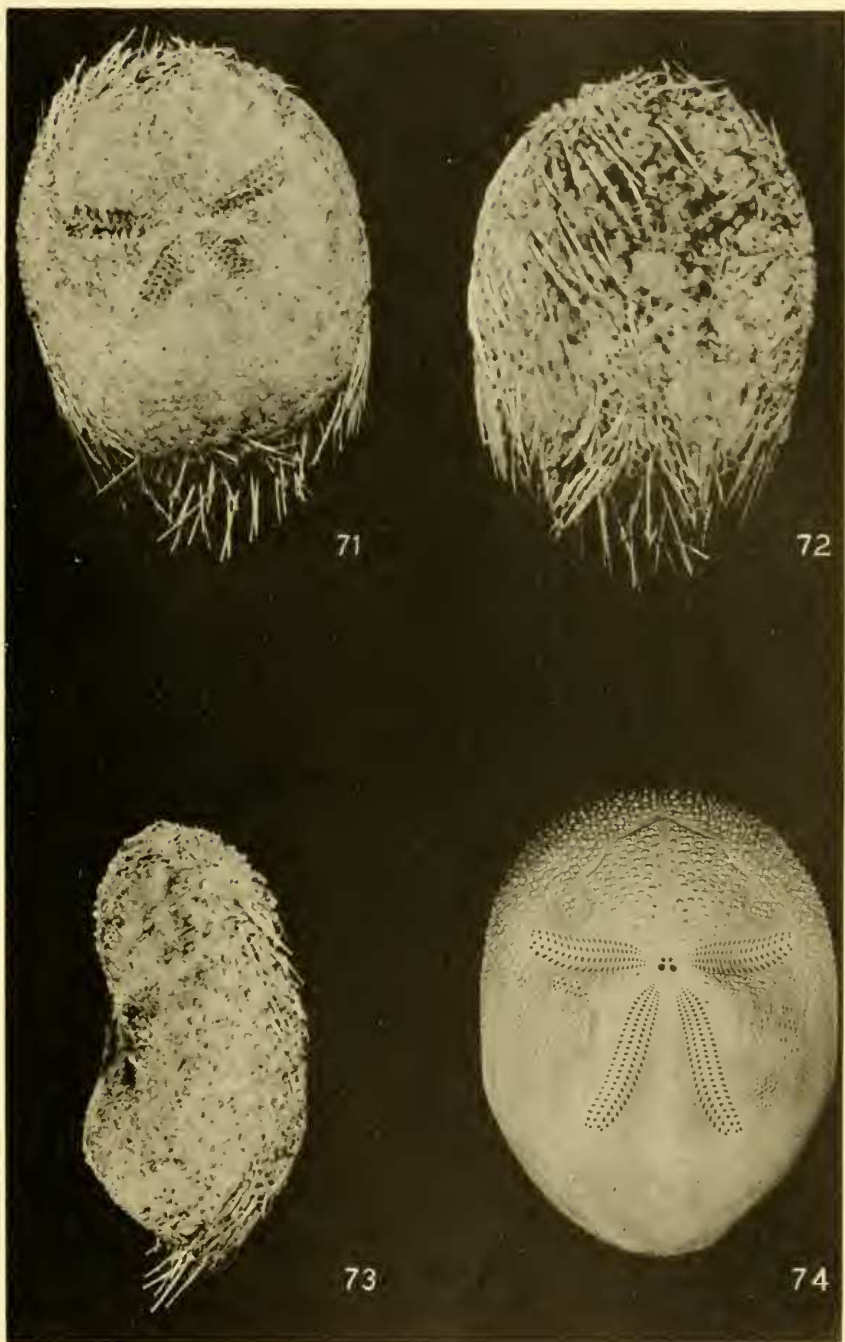
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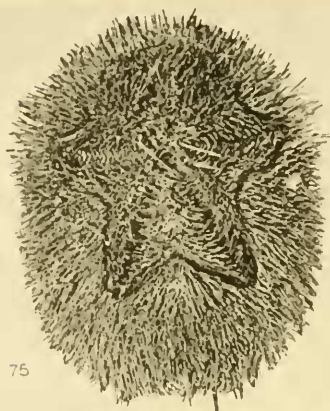


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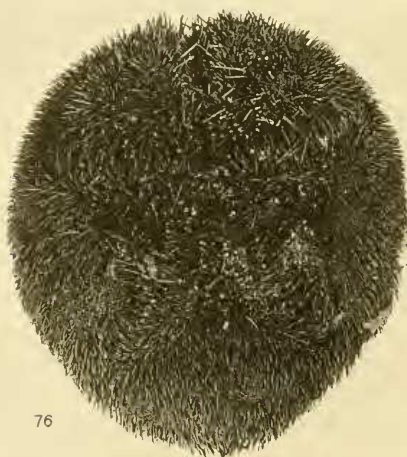




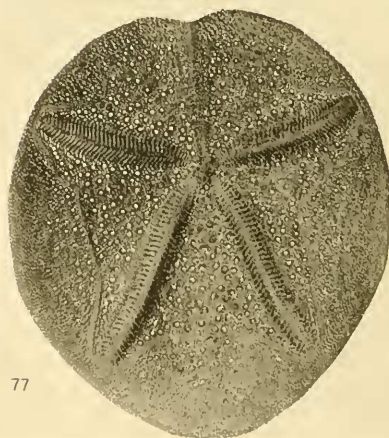




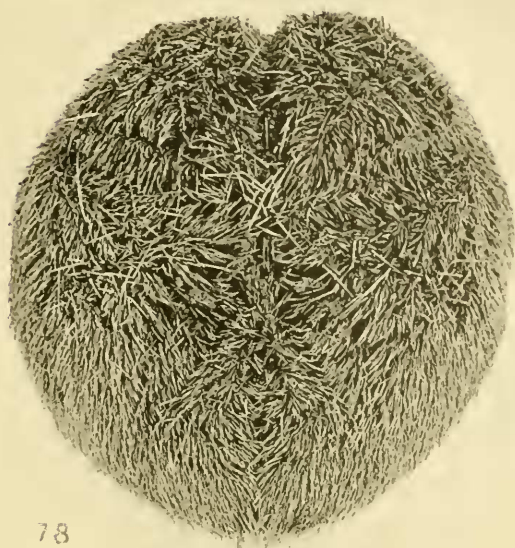
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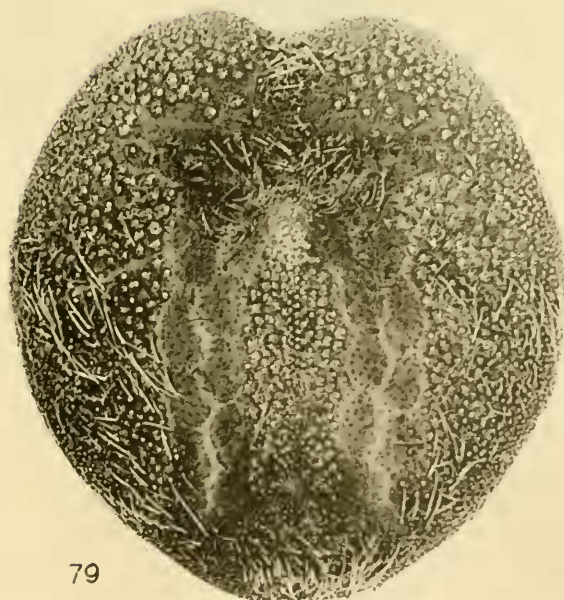
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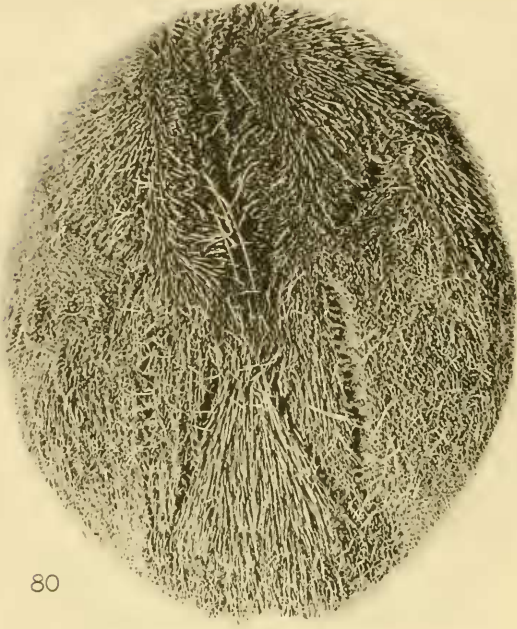
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PLATE 67

- Fig. 71. *Ibiobryssus coelus* H. L. Clark, aboral view, $\times \frac{8}{3}$, p. 343
Fig. 72. *Idiobryssus coelus* H. L. Clark, oral view, $\times \frac{8}{3}$
Fig. 73. *Idiobryssus coelus* H. L. Clark, lateral view, $\times \frac{2}{3}$
Fig. 74. *Brissus latecarinatus* (Leske), aboral view, $\times \frac{2}{3}$, p. 343

PLATE 68

- Fig. 75. *Brissus latecarinatus* (Leske), aboral view with spines, $\times 1$, p. 343
Fig. 76. *Meoma grandis* Gray, aboral view, rough, $\times \frac{1}{2}$, p. 344
Fig. 77. *Meoma grandis* Gray, aboral view, smooth, $\times \frac{1}{2}$

PLATE 69

- Fig. 78. *Spatangus californicus* H. L. Clark, aboral view, $\times \frac{4}{5}$, p. 345
Fig. 79. *Spatangus californicus* H. L. Clark, oral view, $\times 1$

PLATE 70

- Fig. 80. *Gonimaretia laevis* H. L. Clark, aboral view, $\times 2$, p. 347
Fig. 81. *Gonimaretia laevis* H. L. Clark, oral view, $\times 2$

Clypeaster speciosus Verrill

Plate 48, Fig. 29

Clypeaster speciosus Verrill, 1870a, p. 95.

H. L. Clark, 1914, p. 31, pl. 135, figs. 1, 2; pl. 136, fig. 5.

This is the common *Clypeaster* of the Gulf of California and the *Velero* collection contains 143 examples of it, ranging in size from young ones (6-20 mm long) whose specific identity may perhaps be debatable, to full grown adults 120-130 mm long. The width is usually about 90 per cent of the length, but shows considerable diversity ranging from 87 to 95 per cent. The color seems to be very constantly dark purple approaching black; but very young specimens are reddish violet, and orally lighter than on the upper side. The resemblance to the preceding species has been discussed above so that little need be said here, but it may be again emphasized that the line between the two species is often invisible.

Distribution.—This *Clypeaster* is pre-eminently characteristic of the Gulf of California and the *Velero* has not found it anywhere outside the Gulf save at Socorro Island, where a fine series of specimens was secured, and at Clarion Island, where two adults and a half a dozen young *Clypeasters* were taken which may well be referred to *speciosus* for the present. As far north in the Gulf as collecting was done this *Clypeaster* occurs, but south of the Gulf, it is apparently replaced by the preceding species.

Type.—Peabody Museum, Yale University. "None designated as type." (Stanley C. Ball)

Type locality.—La Paz, Gulf of California.

Depth.—Shore to 50 fms.

Specimens examined.—143 specimens from 20 stations.

Clypeaster elongatus⁶, new species

Plate 48, Fig. 30; Plate 49, Fig. 31; Plate 50, Fig. 33

Length 111 mm, breadth 89 mm, height 27 mm; the breadth is thus only .80 of the length, the height about .25. Mouth sunken 15 mm below the sides of the test. Test rather evenly elevated from margin to apex, perceptibly thinner posteriorly. Orally the test is flat near the margins but soon begins to slope to the mouth. Petaloid area about 70 mm long by 60 mm wide. Tuberculation of test quite close and fine with 200 or more tubercles to the square centimeter and 25 or so miliary tubercles to the square millimeter; the tuberculation is slightly more sparse orally than on

⁶ *elongatus*=elongated in reference to the form of the test.

the upper side. Ridges between pore-pairs of unpaired petal (except adapically) with 7 or 8 tubercles rather close together; the miliary tubercles on these ridges scarcely more numerous. Madreporite rather small, about 3 mm across; ocular pores minute, but evident; genital pores distinct but not very large. Unpaired petal nearly 40 mm long, and about 17 mm wide, the interporiferous area some 9 mm, where widest, near middle; there are about 60 pore-pairs on each side and they nearly meet at tip so the petal is virtually closed. Anterior petals rather more than 30 mm long, and 17 mm wide, elliptical rather than oval, and only very slightly open at tip. Posterior petals, similar but longer (36 mm) and wider (19 mm), scarcely more open at tip. Periproct about 5 mm across, scarcely longer than wide, some 3 mm from the test margin, covered with numerous miliary-bearing plates.

Primary spines smooth and blunt, dorsally about 2 mm long but somewhat longer orally and near the mouth they may be 4 or 5 mm long. They are blunt and seem fragile; they may be slightly flattened or thickened at tip but are not noticeably widened. Miliary spines as long as the primaries and excessively slender; with the larger spines they form a close dense coat on the dorsal side; orally they are less numerous and hence the covering of the oral side is notably less dense than dorsally. Pedicellariae numerous and large; there is great diversity in the size but nearly all are tridentate and none are characteristic.

Color of the dry specimen is vinaceous to Hay's brown, aborally; orally the vinaceous tint is more or less replaced by clay color. The oral spines are clay color or lighter with the middle, and often most of the distal half definitely dark vinaceous brown on the upper or outer side.

The unique holotype of this *Clypeaster* was taken December 13, 1934, at Station 347-35 off North Seymour Island, in the Galapagos Islands, on a bottom of sand, rock and shell, in 3 fms. It was first referred to *rotundus*, later to *ochrus* or *speciosus*, but the long, narrow and high test, the unusual coloring and the shape of the petals, preclude reference to any of these known species. Among the scores of *Clypeasters* in the Hancock collection this individual stands out unique. It seems best to give it a name, even if additional specimens are never taken.

Type.—Holotype, AHF no. 47.

Type locality.—Station 347-35, off North Seymour Island, Galapagos Islands, 3 fms, December 13, 1934.

Distribution.—Type locality.

Depth.—3 fms.

Specimens examined.—The type specimen only.

Family **Scutellidae**
Dendraster excentricus Eschscholtz
Plate 49, Fig. 32

Scutella excentrica Eschscholtz, 1831, p. 19.

Dendraster excentricus L. Agassiz and Desor, 1847, p. 135.

Echinarachnius excentricus A. Agassiz, 1873, pl. 13a, figs. 1-4.

There are literally thousands of specimens of this common and characteristic west coast sand-dollar in the *Velero* collection but as rather more than eleven thousand are young individuals less than 10 mm in diameter they offer no help in the almost hopeless attempt to distinguish reliable specific and varietal lines in the mass of material at hand. Leaving obviously very youthful specimens out of account, there are approximately 750 specimens to which it should be possible to attach varietal if not specific names, for the alternative of calling them all *excentricus* is simply an evasion of the problem. After long and critical study of all the usable specimens which are past 30 mm in diameter, and of scores of smaller specimens as well, it seems necessary to recognize 3 species and one named variety in addition to the long known *excentricus*. It should be added at once that this does not leave *excentricus* a constantly well-defined species. Far from it! In the material here identified as *excentricus* sens. str. there are many specimens which differ obviously from a typical individual, though they come from the same region and even from the same station. In the absence of still more abundant material, the only practicable course is to list them as *excentricus*, pointing out the features in which they are puzzling.

Normal specimens may reach a very large size, the largest coming from the northern stations. Specimens from the Oregon coast are frequently 75 mm long, 80 mm wide and 12-14 mm high (or thick); the largest in the *Velero* collection is 87 mm long and 95 mm wide. Ordinary specimens from Monterey and southward are usually less than this, a typical specimen being 65 x 70 x 9 mm but there is a great deal of diversity in shape and stoutness. Among the Channel Islands and south to Corona del Mar, this sand-dollar is very common in shallow water, from low water mark down to at least 40 fms. South of the Mexican line there seems to be a tendency to a more elongate form and a variety *elongatus* was described in 1935 (H. L. Clark, p. 122). The present collection contains few specimens that can be referred to this variety and 8 of these are young bare tests (bleached), 7 from the vicinity of Cedros Island, Lower California and 1 from off San Nicolas Island, California. A fifth specimen is very different in appearance from these tests for although it is also

bare it is not at all bleached but is a fine shade of brown, with the dark brown lines of the posterior half of the test (one of the supposed characters of *elongatus*) very conspicuous. It is from Laguna Beach, California, and measures 62 x 63 x 9 mm. One other specimen, also bare and not bleached, measures 39 x 37 x 5 mm and is of the same color and texture as specimens of the same size of the species of *Dendraster* described below as *laevis*. The petaloid area shows clearly that it is not *laevis* and hence it would seem to be an odd *elongatus*.

Several other specimens show peculiarities that distinguish them as not normal. Two of these deserve a few words of description. The smaller, although not truly circular measures 43 x 43 mm. The anterior petal is long and narrow with a relatively uncrowded tuberculation, while the anterior paired petals are notably long and open at the tip. The color is a brown orange, particularly bright on the oral surface. It was taken north of Anacapa Island, California, in 15 fms. The other peculiar specimen measures 55 mm long by 61 mm in breadth. The anterior margin is nearly straight for about 15 mm while the posterior is straight for 20 mm or more. The apex of the test is about 30 mm from the anterior margin but the madreporite and the adjoining petal-bases are only 18 mm from the posterior margin. Associated with this, the lateral petals are unusually diverging, the tips of the posterior pair being 22 mm apart. The anterior pair are also markedly diverging and very long, their tips 35 mm apart. The color of the test where bare is dull purple. The dense coat of spines is more or less orange or yellow but the color of the test is dominant on the upper surface; hence the general effect of the upper side is dark, dull brown orange; the lower side is predominantly brown orange.

Coloration in *excentricus* is generally dull but shows a considerable diversity. The specimens from Oregon are essentially gray, the lighter with a tendency to cream color or dull white, especially orally, the darker ones to a dusky brown or even black. Most California specimens tend towards either a dull violet black or a bright maroon brown; the latter in some cases might be called dark red. Owing to the dense coat of spines on the lower surface, the oral side is usually lighter or more brightly colored than the upper. As *Dendrasters* often congregate in great numbers on suitable bottoms, they tend to crowd each other into a more or less vertically inclined position and thus lie tier upon tier on a rough bottom over which the tidal currents flow back and forth. As a result of this the anterior fourth (more or less) of the animal becomes bleached to some degree while the not buried part remains dark. This peculiar bicoloration may be quite striking.

Distribution.—The *Velero* has taken *excentricus* at 42 stations, of which the northernmost was on the Oregon coast, 43° 41' N Lat. and the most southern near the tip of Lower California. No specimens have been taken at the Galapagos Islands or near any of the off shore islands. The great bulk of the material is from shallow water, out to about 20 fms, for the most part, but a few specimens have been taken in 40-50 fms and one specimen is labeled as from 113-127 fms, southeast of Marcial Point on the east coast of Lower California. There is perhaps some mistake about this label as no other specimens are known from the Gulf. Other authors extend the range to Alaska.

Type.—Unknown.

Type locality.—"An der Küste der Insel Unalashka, am Kamtschatischen Meere." (Grant and Hertlein, 1938, p. 84)

Depth.—Shore to 50 fms.

Specimens examined.—Approximately 12,316 specimens from 42 stations.

***Dendraaster laevis*⁷, new species**

Plate 50, Figs. 34-36

Length 52 mm, breadth 57 mm, height 6 mm; the breadth is thus markedly greater than the length; in young specimens, however, the length may be greater, a specimen 30 mm long is only 28 mm wide; the largest specimen is 68 mm long, 75 mm wide and 8 mm high. Lower surface perfectly flat, the mouth not depressed at all. Both mouth and periproct are remarkably small, the former 2 mm, the latter scarcely 1 mm across. The petaloid area is remarkably small, only about 26 mm long by 29 mm across; the apex is 30 mm from the anterior margin. Anterior petal is longest but the anterior paired petals are nearly as long, 15 to 15.5 mm; posterior petals about 11 mm. All the petals are about 6 mm wide. The pore-pairs are so small and the tuberculation of the whole test is so fine, there are no very evident distinctive features, but the pore-pairs make a single narrow band along each side of each petal; the intermediate area is quite uniformly covered with minute tubercles. The four genital pores are quite evident but the ocular pores are indistinct. Both above and below the outlines of the plates composing the test are clearly shown and the pattern they make is striking. This feature is not at all evident in either the larger specimens or in the bare tests but it is a very handsome feature of the holotype. Primary spines short and slender, knobbed at the tip,

⁷ *laevis*=smooth, in reference to the remarkably close coat of delicate spines.

lying flat and close so that the surface of the test is relatively smooth, quite unlike the condition in the other species of the genus. Pedicellariae very small and not abundant or peculiar. At each mouth angle is a group of 8-10 slender, acute primary spines, lying almost horizontally over the mouth. Color old gold orally, more nearly deep colonial buff aborally. In the largest specimens the color is very dull, especially on the upper side; orally the yellow-brown shade is very evident.

This very distinct species was taken by the *Velero* at 9 stations between San Miguel Island, California, and the Coronados Islands, Mexico, in 4-30 fms. While most of the 118 specimens are young or very young, large adults were taken at 5 stations. The young are commonly quite yellow but the big adults are rather dull colored. A bare test when carefully cleaned revealed well the extraordinarily small petaloid area. The very small size of mouth and anus is another striking feature.

Type.—Holotype, AHF no. 48, 82 paratypes.

Type locality.—Station 976-39, north of Santa Barbara Island, California, 15-20 fms, May 28, 1939.

Distribution.—Channel Islands, California to Coronados Islands, Mexico.

Depth.—4-30 fms.

Specimens examined.—The type, paratypes and 35 specimens, from 9 stations.

***Dendraster mexicanus*⁸, new species**

Plate 51, Figs. 37-39

Length 60 mm, breadth 60 mm, height 9 mm. Lower surface nearly flat, the mouth a little sunken. Test rather evenly elevated from margin to apex which is about 28 mm from posterior margin. Madreporite just posterior to apex. Petaloid area 32 by 33 mm with the anterior petal 18 mm and each of the anterior laterals about the same. Tuberculation of test very close and fine near margin but distinctly coarser on the elevated part of test, particularly within the petals; on oral surface the tuberculation is coarser and more widely spaced. Posterior petals about 15 mm long and 8 mm wide; they are slightly curved and diverge markedly, the inner margins being 15 mm apart at tips; poriferous areas very wide (about 3 mm), the ridges between the pore-pairs are very narrow but carry a crowded series of 3-9 minute tubercles. Areas between the poriferous zones carry fairly numerous, but not crowded tubercles of diverse sizes;

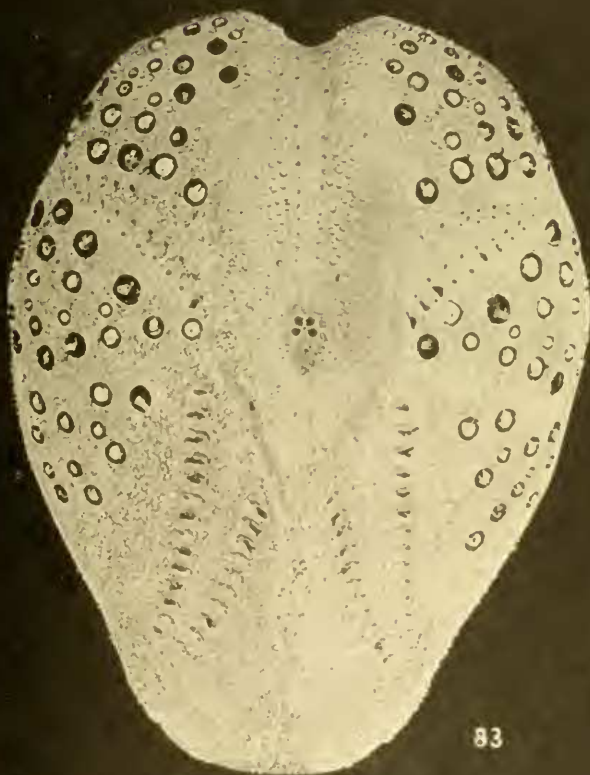
⁸ *mexicanus*, in reference to the southern habitat of the species.

PLATE 71

- Fig. 82. *Lovenia cordiformis* A. Agassiz, aboral view, rough, $\times\frac{2}{3}$, p. 347
Fig. 83. *Lovenia cordiformis* A. Agassiz, aboral view, smooth, $\times 2$



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83

none are conspicuously large but many are larger than the tubercles of the interradiial areas. Anterior lateral petals similar in general tuberculation but the great breadth of the poriferous zones is very striking; the petals are 9 mm wide and the interporiferous area is only 3 mm. There are 8-10 (or even more) tubercles in each series across the poriferous area. Anterior unpaired petal is similar to the other petals but is perhaps a trifle narrower. Abactinal surface densely covered with spines of which those covering the interporiferous part of each of the paired petals are 2 or 3 mm long. This series of long spines forks at the distal end of the petal and continues to the test margin. Between petals 1 and 2 (as well as between 4 and 5 and 1 and 5) there are 2 parallel series of long spines running to the disk margin, where all spines are 3 or even 4 mm long. This belt of long spines forms the outer margin of the disk. Orally, the primary spines are 3-5 mm long, cinnamon buff to light purple drab in color and contrast decidedly with the dark purple drab of the disk. Pedicellariae very numerous, chiefly minute ophicephalous⁹ or triphyllous, crowded among the spines. Color of bare test dark purple drab; of the spine coat, light brownish drab.

There are 7 adult specimens of this *Dendraster*, of which 2 are more or less cinnamon brown while the other 5 are of varying shades of purple drab. The latter, including the holotype, are from San Rosario Bay, west coast of Lower California, in 15 fms. The other 2 and 13 very young individuals, 11-16 mm across, are from Lagoon Head Anchorage, west coast of Lower California, in 7 fms. The rough appearance of the posterior part of the dorsal surface, due to the long spines in radiating series (much as in *rugosus*) is a notable feature of this species but is not as important as the character and appearance of the petals on the cleaned test.

Type.—Holotype, AHF no. 49, 4 paratypes.

Type locality.—Station 610-37, Rosario Bay, Lower California, 15 fms, February 28, 1937.

Distribution.—West coast of Lower California from Rosario Bay to Lagoon Head Anchorage.

Depth.—7-15 fms.

Specimens examined.—The type, paratypes and 15 specimens from 2 stations.

⁹ It is regrettable that Clark gives no information about these ophicephalous pedicellariae otherwise found only in *Echinodiscus* and (young) *Astriclypeus* among Scutellids. It would have been particularly interesting to learn whether they are bivalved as the other pedicellariae, bivalved ophicephalous pedicellariae being otherwise a very great rarity. In a couple of specimens of this species, a young one and a fine adult specimen, sent me by Prof. McCulloch, I do not find a single ophicephalous pedicellaria.

***Dendraster rugosus*¹⁰**, new species

Plate 52, Figs. 40-41

Length 49 mm, breadth 47 mm, height 9 mm; the breadth is thus very nearly equal to the length and it is probable that in fully grown individuals the equality is complete. Lower surface almost completely flat, the oral area being very slightly depressed (when the animal is upside down). Test rather evenly elevated from margin to apex, which is definitely posterior in position, less than 20 mm from posterior margin. Petaloid area 26 by 30 mm with the anterior petal the longest and narrowest. Tuberculation of test very close and fine abactinally but with numerous primary tubercles scattered irregularly about, mostly in the petals or near the test margin; tuberculation of oral surface rather sparse except near margin. Posterior petals about 11 mm long and 5.5 mm wide; they are quite straight and diverge markedly, the inner margins being 12 mm apart at tips; poriferous areas very narrow, about a millimeter wide, and the ridges between pore-pairs are so narrow they carry no primary tubercles. The areas between the poriferous zones carry longitudinal series of relatively large tubercles, about 4 basally but only 2 or 1 near the tips; these series are more or less irregular and incomplete but give a definite character to the petals. Anterior lateral petals essentially similar but larger, 14 by 6.5 mm; the poriferous zones are wider than in the posterior pair but are still quite narrow. The anterior unpaired petal is about 16 mm long but only 5 mm wide, for the poriferous zones are only a little curved and are as narrow as possible. Interporiferous areas in all 3 anterior petals show their primary tubercles rather conspicuously in 4 somewhat imperfect but still evident longitudinal series. Whole abactinal surface closely covered with spines; the primary spines, borne by the large tubercles of the petals and by similar tubercles scattered over the interambulacral areas, are about 2 mm long, nearly white and rather sharp, the other spines are scarcely half as long and are thickened at the tip and rather bluntly pointed. Genital pores 4, fairly large; the 5 ocular pores much less distinct. Mouth small, largely concealed by the long (4 or 5 mm) white spines crowding around it. Anterior primary spines of oral surface, 2 or 3 mm long, curve outwards to left and right on the anterior fifth of the test. Pedicellariae very small and hard to detect, not distinctive. Color of bare test pale ecru drab or pale vinaceous drab, spines whitish.

¹⁰ *rugosus*=rough, in reference to the appearance caused by the numerous projecting primary spines.

There are 4 specimens of this interesting *Dendraster* in the *Velero* collection. The holotype is the largest, with the others 37-39 mm long; the smallest 36 mm wide. They resemble the type in color and in every other respect. They were taken in Bay San Sebastian, Vizcaino, west coast of Lower California, in 17 fms on a sandy bottom. The delicate coloration, the long white primary spines and the very narrow poriferous zones are quite distinctive.

Type.—Holotype, AHF no. 50, 3 paratypes.

Type locality.—Bay San Sebastian Vizcaino, Lower California, 17 fms, August 28, 1932.

Distribution.—Bay San Sebastian Vizcaino, Lower California.

Depth.—17 fms.

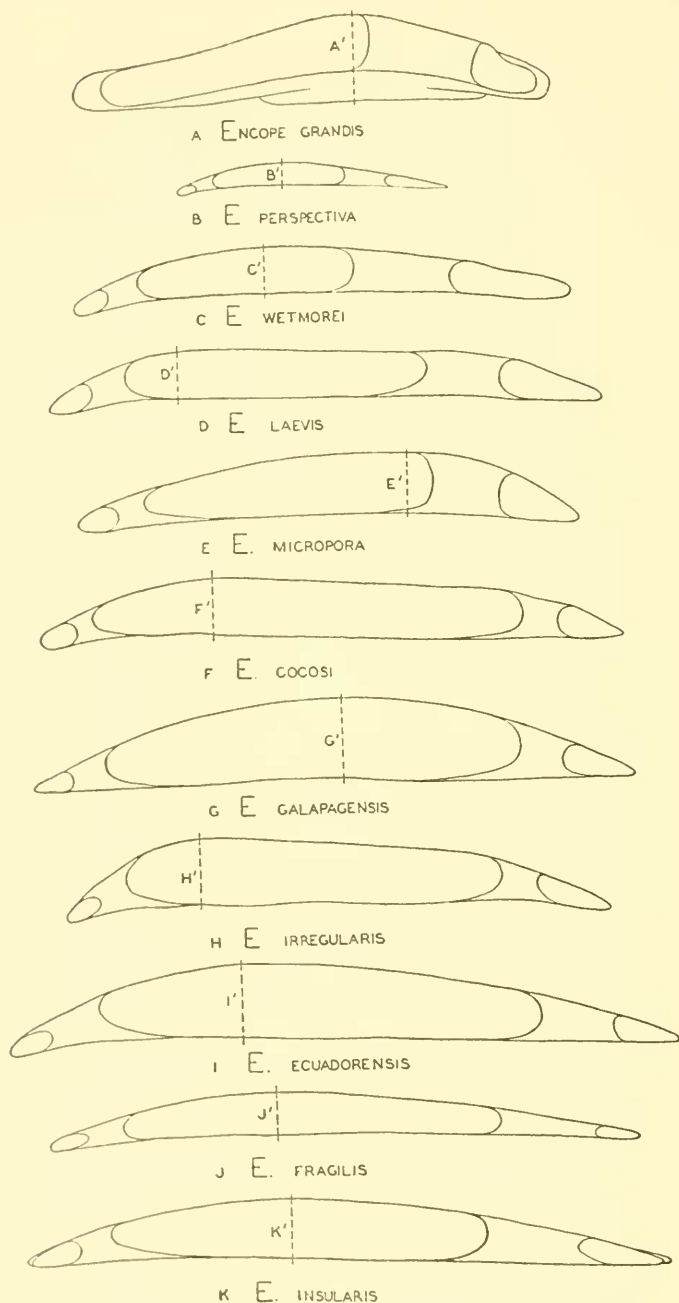
Specimens examined.—The type and paratypes from 1 station.

Genus ENCOPE L. Agassiz

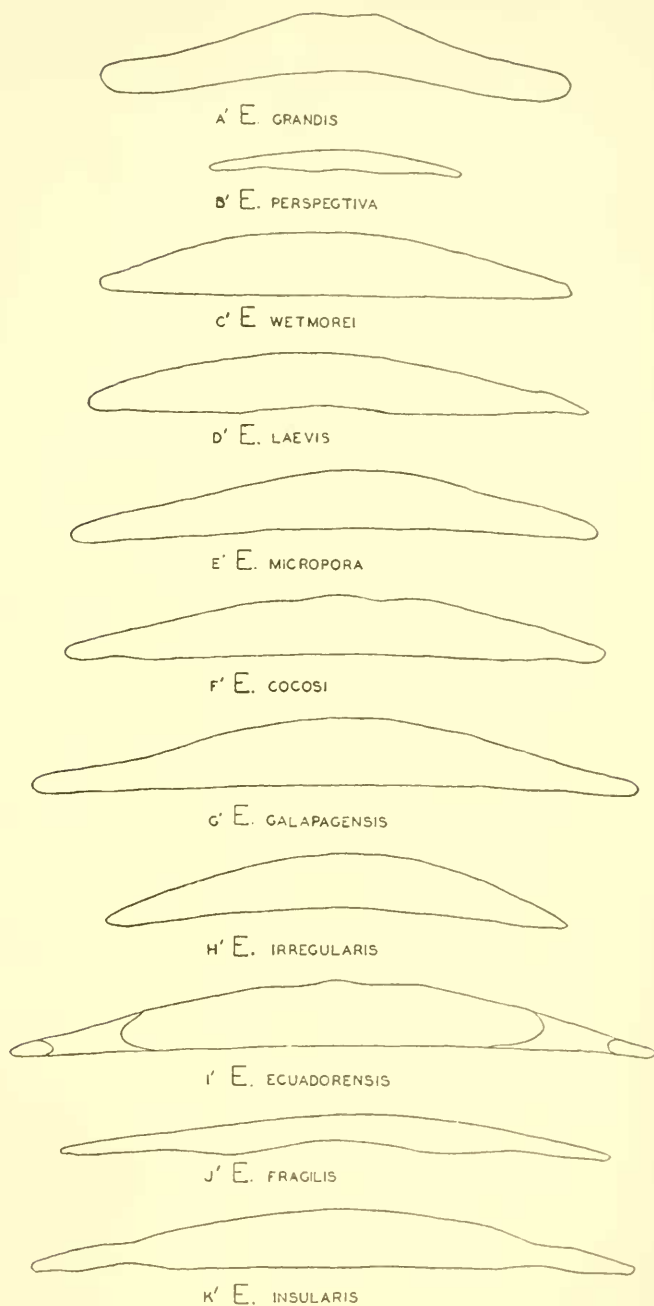
In establishing the genus *Encope* L. Agassiz (1840, Cat. syst. ectyp. Echinod. Mus. Neocom. p. 6; 17) mentions only the species *grandis*. This species accordingly is the genotype. To take a species not originally included in the genus as the genotype is against the rules and against common sense. In a letter to me of May 8th, 1947 (the last but one he wrote to me) Clark writes: "A young palaeontologist here (viz. Dr. Durham) who is working on a Monograph of fossil *Encopes* insists that *grandis* is the type. As you of course know, I consider that *emarginata* is the type. If you agree with him that *grandis* is the type, I'll have to make some changes in my MS; but if you agree with me that *emarginata* is the type then I shall be comfortably settled. At any rate *grandis* and *emarginata* are not congeneric, so one of them must have a new name."

It is clear that Clark thus leaves to me the decision of the question which species is the genotype of *Encope*—and there cannot be the slightest doubt but that *grandis* is the genotype. Further, I thoroughly disagree with Clark in seeing two different generic types in *grandis* and *emarginata*. The only noteworthy difference is that the edge of the test is thicker in *grandis* than in the other species; but whether the edge is some 5 mm or only 2-3 mm thick is certainly not a difference of generic value, and any difference of morphological value does not exist between *grandis* and the other species. Particularly it must be emphasized that the internal structure is exactly alike in both.

As said in the preface I think Clark is here making too many species; but without having access to the collections on which he is basing his



Text figure 1. Outline drawings at median longitudinal axis of the species of *Encope* illustrated on Plates 53-59.



Text figure 2. Outlines of transverse sections of same specimens at areas of greatest thickness or height.

various species I cannot go into a critical valuation of them, and I think it therefore the only fair thing to publish this part of his manuscript as he left it. Future investigations will have to decide about the value of all these species.

One more species, *Encope Stokesii* L. Agassiz will have to be added to the West American species of *Encope*. Clark gradually became convinced that this species is only the young of *micropora*, but this is decidedly a mistake. The internal structure of the test is markedly different from that typical of *Encope*, the buccal cavity being not closed as it is in *Encope* but remaining in open connection with intestinal cavity. The subgenus *Mellitella* established by Duncan (1889) for this species is therefore fully justified—perhaps it should rather form a genus of its own.

It is very improbable that this species, so fairly common in the warmer region of West American seas, should not be represented in the *Velero* collections. Specimens of this species have probably been identified by Clark as *Encope micropora*. A re-examination of his material will be needed for settling this matter.

Encope (Mellitella) Stokesii will be dealt with fully in the forthcoming Vol. IV.2 of my Monograph of the Echinoidea. Th. Mortensen

The very large number (1,212) of *Encopes* taken by the *Velero* in her voyages to the tropical Pacific has necessitated a very detailed and time consuming comparative study of this well-defined and easily recognized genus. It was soon evident that more species of *Encope* are living on the western coast of tropical America than had been hitherto supposed and that the specific lines drawn needed realignment. In July, 1946, Austin Hobart Clark of the United States National Museum published a "Revision of the Pacific Species of the Genus *Encope*" with the description of a well-marked new species and the recognition of two new subspecies and a new variety. No statement as to the number of specimens available is made but Mr. Clark tells me that both the subspecies are based on "bare white tests devoid of spines." There are very few bare tests in the *Velero* collection and the identification of such tests is a difficult matter, with the possibility of error being very large, unless specimens with spines from the same locality accompany them. The hundreds of *Encopes* available from the Gulf of California show that the *Encopes* there are either the well-known form here listed as *Encope grandis* or *micropora*. It is fruitless to try and recognize either *borealis* or *californica* as subspecies or varieties, as they lack any constant association with any locality or any large group

of specimens. On the other hand what Mr. Clark calls *micropora galapagensis* is a very well-marked species, not found elsewhere and apparently the only *Encope* found at the Galapagos Islands. If the type *perspectiva jonesi* really came from these islands, it is strange nothing like it occurs in the *Velero* collection. Its being a bare test debars it from further consideration in this report.

The following key to the eleven species of *Encope* here recognized will require modification when more material from the Central and South American coast is available.

- A. Unpaired lunule in between the posterior petals for at least most of its length.
 - B. Covering of test dorsally made up of rather slender spinelets the tips of which are swollen but not flat-topped, nor inverted; cones more or less considerably in contact *perspectiva*
 - BB. Covering of test dorsally made up of spinelets whose tips are more or less evidently inverted cones.
 Covering of test a fairly smooth pavement of cone-bases loosely in contact; color dark olive-gray *wetmorei*
 Cone-bases larger and in close contact, making a very smooth pavement; petals very large, straight, wide at tip; color olive-brown or darker with marginal fringe of short brown or reddish-brown spinelets; lower surface brown *laevis*
- AA. Unpaired lunule not forward between posterior petals but more or less in line with the posterior lunules or anterior to them.
 - C. Lunules usually more or less circular or oval and relatively small; test usually less than 120 mm in length, commonly about 90-100 mm. Spines of test very slender with only slightly enlarged tips *micropora*
 Test covered with the very numerous slender spines, each tipped with an oval ball, commonly white or light colored *cocosi*
 - CC. Lunules much longer than wide; test often wider than long.

- D. Lunules about twice as long as wide; test thick and heavy, the margins a couple of millimeters or more in thickness.
- E. Test large, up to 150 mm h. d.; unpaired lunule usually longer than posterior pair, its anterior end a little in advance of the other two; test high, flattened between tip of anterior petal and the posterior lunule, highest point may be determinable as in middle or at either end; normal color light brown above, with disk and lunule margins purple *galapagensis*
- EE. Test smaller; unpaired lunule about the same size and about in line with posterior lunules. Color dark gray or blackish. Test flattened on top, commonly irregular in outline, its greatest height about one-sixth or one-seventh of length; lunules relatively small and narrow, the posterior three nearly in line *irregularis*
 Test more curved on top, oval or broadly oval; its height about one-tenth of length; lunules long and narrow, the anterior trio slightly smaller *ecuadorensis*
- DD. Lunules 3 to 4 times as long as wide; test thin and light with relatively thin edges. Unpaired lunule wider than other lunules; its anterior tip little or not at all in front of the posterior pair *fragilis*
 Unpaired lunule long and narrow, its anterior end well in advance of the posterior pair *insularis*

In this key Clark, according to his views did not include the species *grandis*. It is easily distinguished from the rest of the species by its margin being thicker, some 5 mm or even more. Th. Mortensen

Encope grandis L. Agassiz

Plate 53, Fig. 42

Encope grandis L. Agassiz, 1841, p. 57, pl. 6.

This easily recognized sea-urchin, or key-hole urchin, is very abundant in the Gulf of California and the *Velero* has brought home no fewer than 1,222 specimens, ranging in size from 40 x 40 mm to the big adults exceeding 100 mm in length with a breadth usually somewhat less but often somewhat greater. The largest specimen in the collection is 116 mm long by 111 mm wide and 16 mm thick, while another individual from the same station (689-37) is 111 mm long by 115 mm wide and 16 mm thick. The percentage of the total weight which the skeleton makes is very great but has not been worked out. Although the coarse and heavy build makes the specimens unmistakable, there is extraordinary diversity in the posterior unpaired lunule, which ranges from nearly circular to a long and narrow slit. The most striking case is a specimen 100 x 90 mm in which the lunule is circular and only 3 mm in diameter. This is such an extreme case it is probably pathological. At the other extreme is an individual with the lunule 20 mm long but only 6 mm wide. There is apparently no correlation between size or weight of the individual and the size of the lunule. Thus a specimen 100 x 105 mm has the lunule 17 x 10 mm but another specimen from the same lot, 92 x 92 mm has the lunule 33 x 16 mm. The color is dull purple, approaching black, or some shade of brown, ranging from fawn color in some young individuals to very deep blackish brown in adults. The marginal area is often darker than the center and the lower surface is lighter than the upper, often markedly so. But there is no distinctive feature in the coloration.

Distribution.—The *Velero* took *grandis* at only 10 fathoms, all in the Gulf of California, mostly along shore, but occasionally it was dredged in from 1 to 10 fms. The scarcity of young individuals or even small adults is striking but may be associated with the fact that all the material was collected between January 30 and March 23. Perhaps collections made in summer or early fall would show a larger number of young.

Type.—(Germany?)

Type locality.—" . . . provient probablement des Antilles."

Depth.—Shore to 10 fms.

Specimens taken.—1,222 specimens from 10 stations.

Encope perspectiva L. Agassiz

Plate 53, Fig. 43

Encope perspectiva L. Agassiz, 1841, pp. 51, 146, pl. 10b, figs. 1-5.

A. H. Clark, 1946, pl. 3, upper fig.

It is a curious thing that this well characterized species is not adequately represented in the Hancock collection. In fact the only *Encopes* which can be referred to it with any confidence are 5 young ones and 2 fragments which were taken at Station 485-35 in Tenacatita Bay, Jalisco, Mexico, in 5 fms on a bottom of sand and shells. They range from 37 x 39 mm to 56 x 58 mm and are exceedingly thin and flat. The unpaired lunule is well forward between the hind pair of petals and is the largest of all. The spine-covering of the dorsal side of the test is made up of countless spinelets whose tips are ovate balls—a distinguishing feature of *perspectiva*. The color ranges from Lincoln green, through dusky olive green to dusky yellow green. The lower surface is brown, with more or less gray on the ambulacra. The *Velero* did not take an adult example of this well-marked species at any other place, but in March, 1939, she dredged, at Chacahua Bay, Mexico, some distance southeast of Tenacatita Bay, 14 specimens of very young *Encopes*, which have notably long, narrow unpaired lunules and are apparently young *wetmorei* or *perspectiva*, presumably the latter.

Distribution.—Known range from other authors, Ballenas Bay, Lower California to Costa Rica.

Type.—Unknown.

Type locality.—Unknown.

Depth.—5-15 fms.

Specimens examined.—21 specimens from 2 stations.

Encope wetmorei A. H. Clark

Plate 54, Fig. 44

Encope wetmorei A. H. Clark, 1946, p. 2, pl. 1; pl. 2, fig. 1.

This interesting new species, so recently described, may be distinguished at once by the anterior position of the unpaired lunule, which lies well in between the posterior petals, and by the peculiar character of the spinules which cover the dorsal surface. These spinules have inverted conical tips, the bases of the cones forming a more or less smooth pavement covering the upper side of the test. This pavement is not so continuous or smooth as in the following species but is very faintly rough or "furry." The spines around the unpaired lunule are relatively long (3 mm or 4 mm), flat

and truncate. Around the other lunules they are smaller and more slender. The bare test is a distinct gray but the spine covering is a very dark shade of olive gray.

There are 4 specimens of *wetmorei* in the collection, each about 100 mm long with a width nearly or quite as great. One specimen is injured posteriorly so that the unpaired lunule has never been cut off at the rear. The other 3 specimens are symmetrical and uninjured. All of these specimens were taken in 5-10 fms on the south side of Petatlan Bay, Guerrero, Mexico, in March 1934. Besides these adults there are 32 very young *Encopes*, 6-15 mm in diameter, taken in 25 fms south of White Friars, near Petatlan Bay, which may be referred to *wetmorei* as they are apparently not *perspectiva*, and the position of the posterior lunule indicates they must be one of the two species.

Distribution.—Mazatlan, Mexico, to Pearl Islands, Panama.

Type.—U.S.N.M. No. E. 6768.

Type locality.—San José, Pearl Islands, Bay of Panama.

Depth.—5-25 fms.

Specimens examined.—36 specimens from 2 stations.

***Encope laevis*¹¹, new species**

Plate 54, Fig. 45; Plate 55, Fig. 46

Length 117 mm, width 115 mm, height 12 mm. Test stout, relatively heavy and quite flat dorsally; highest point only about 25 mm from anterior margin, thence it slopes very gradually and slightly to the unpaired lunule, the margins of which are a little elevated; height of test there about 10 mm; posterior margin of test slightly convex but in other specimens it may be quite straight. Unpaired petal about 40 mm long, 21 mm wide some 10 mm from the tip, which is nearly but not quite closed; poriferous zones very wide (6 mm) with the narrow, crowded ridges each bearing some 25 minute tubercles, of about the same size as those which densely cover the median area. Anterior lunule small, about 6 mm long by 2 or 3 mm wide, 8 mm from the margin. Anterior paired petals about 40 mm from anterior margin only about 10 mm in front of the madreporite which is very large (10 mm) and densely granulated; the petals are about 35 mm long and 20 mm wide near the blunt tip; their lunules are only about 9 or 10 mm from test margin and only a little larger than the unpaired one. Posterior petals 42 mm long and 20 mm

¹¹ *laevis*=smooth, in reference to the remarkably smooth upper surface.

wide near the very blunt tip, their lunules are a little longer (about 8 mm) but scarcely wider than the anterior 3. Unpaired lunule nearly 12 x 3 mm, and almost wholly within the area limited by the posterior petals. Its surrounding spines are relatively long (2-4 mm) flattened, particularly at the somewhat truncated tips, which, however, are not chisel-shaped. Entire upper surface of test densely covered with very low spines each of which is an inverted cone; the bases of these cones form a very smooth secondary surface for the upper side of the animal. Only around the lunules and at the very margin of the disk are there really spinelets and these are definitely blunt, though the tips of many are rounded at the corners. Lower surface as usual in the genus, the spines long and slender (4-5 mm) but lying more or less flat against the test, pointing towards the mouth on interambulacra 1 and 4 and towards the margin on interambulacra 2 and 3; on interambulacrum 5 they all tend to point towards the lunule, as they do on the five ambulacra.

No two of the 33 specimens are exactly alike in color, but in general they may be called olive brown lighter towards the center. Many specimens are darker than the holotype, appearing to be clove brown or even bone brown. None, however, approach the olive gray (almost deep green) of *wetmorei*. The marginal spines and the lower surface are definitely brown lacking the olive tint. The cleaned test where bare and dry (but not at all bleached) is a pale olive gray rather markedly in contrast with the normal olive brown of the spine-coat. While this species resembles both *perspectiva* and *wetmorei* in the position of the posterior lunule, it cannot well be referred to either one. It seems best to regard it as a related but distinct species. A specimen, for deposit in the National Museum, was sent to Mr. Austin Clark. He, however, fails to see any essential difference between it and *wetmorei*. Further careful study of the material at hand compels me to maintain *laevis* as a well-marked species.

Distribution.—All of the specimens of this species are from Station 962-39, 11 miles northwest of Corinto, Nicaragua, in 1-3 fms on a bottom of sand and dead leaves.

Type.—AHF no. 51, 32 paratypes.

Type locality.—Station 962-39, 11 miles NW of Corinto, Nicaragua, 1-3 fms May 4, 1939.

Distribution.—Nicaragua.

Depth.—1-3 fms.

Specimens examined.—The type and paratypes, from 1 station.

Encope micropora L. Agassiz

Plate 55, Fig. 47

Encope micropora L. Agassiz, 1841, pp. 50, 146, pl. 10a, figs. 4-8.*Encope californica* Verrill, 1871, p. 586.*Encope micropora* var. *borealis* A. H. Clark, 1946, p. 6, pl. 4.

The very large series of *Encopes* from the Gulf of California is convincing evidence that there is but one species of *Encope* in that Gulf [besides *E. grandis*.] The *Velero* collection included 712 specimens from 21 stations. They range in size from 6 to well over 100 mm in diameter. The finest specimens are from south of Mangles Anchorage, on the west side of the Gulf, in Lat. 26° 16' 55" N, in 3-5 fms and from Puerto Refugio, Angel de la Guardia Island, Lat. 29° 42' 37" N, along a rocky shore. The largest measures 127 mm long by 130 mm wide and 13 mm high. The only *microporas* in the collection from outside the Gulf of California are a handsome specimen, 105 x 104 mm and two very young ones (16 and 17 mm across), collected on the west coast of Lower California, at Lagoon Head Anchorage (28° 12' 25" N) Station 612-37, in 7 fms and a small bare test from San Juanica Bay, (Station 615-37). The attempt to distinguish varieties *borealis* and *californica* fails completely in the light of this abundant material, which is notably homogeneous in general appearance even though the color ranges from a deep brown, almost a purple brown, through chocolate brown, red brown or deep yellow brown to a sort of fawn brown. The position of the apex of the test ranges from well anterior to distinctly posterior but the character is not associated with any other distinctive feature and seems to have no taxonomic value.

Distribution.—According to other authors, *micropora* ranges from Lower California to Peru and the Galapagos Islands. (The Galapagos records are probably based on what is here treated as *E. galapagensis*.)

Type.—Paris Museum.

Type locality.—M. Stokes "mais il n'en est aucun dont l'origine me soit connue."

Depth.—Shore to 16 fms.

Specimens examined.—712 specimens from 21 stations.

*Encope cocosi*¹², new species

Plate 56, Figs. 48-49

Test large, stout, with small lunules. Length 120 mm and width the same; height, greatest about 35 mm from anterior margin, 12 mm; test slopes very gradually to the interambulacral lunule and then rather sharply to margin. Unpaired petal about 40 mm long by 16 mm wide, open by 3 or 4 mm, only 5 mm back of the lunule; poriferous areas about 4 mm wide, the intermediate area 8 mm. Tuberculation of test very fine and close, the petal-ridges with a single closely placed line of some 20 minute tubercles. Anterior lunule small, oval, about 6 x 4 mm, only 5 or 6 mm from test margin. Anterior paired lunules rather far back, a line joining them would be 50 mm from anterior margin of test; they are very small (6-8 mm long, 4-5 mm wide) and only 6-8 mm from test margin. Adjoining petals short and stout, about 33 x 18 mm, ending about 10 mm from lunule. Posterior petals markedly longer (40 mm) than anterior pair, about 18-20 mm wide. Interambulacral lunule small (9 x 4 mm), a little smaller than the posterior pair (10 x 5 mm) which virtually accompany it, as the 3 lie in a straight line parallel to the nearly straight posterior margin of test. Lower surface relatively uneven as the ambulacral furrows are evident and the vicinity of the lunules depressed. Spines of abactinal surface very numerous, short and slender, each one terminating in a conspicuously swollen light brown tip, resulting in a relatively smooth surface; only around the margin and the lunules are the spines elongated and somewhat pointed. Color clove brown becoming warm sepia on the margin; the lower surface is unusually evenly dark with little difference between the ambulacral and interambulacral areas.

Besides the holotype there is only one other *Encope* in the collection similar to this one in form and structural details and it is noticeably different in color as the swollen tips of the spines are very light cream color, resulting in a very definite drab upper surface; the lower is a deep bone brown. Both the brown and the drab specimens were taken in Wafer Bay, Cocos Island, Costa Rica, in 2-4 fms. Although apparently a derivative from the *micropora* stock, it is easily distinguished by the primary spines.

Type.—Holotype, AHF no. 52, 1 paratype.

Type locality.—Station 108-33, Wafer Bay, Cocos Island, Costa Rica, 2-4 fms.

Distribution.—Cocos Island.

Depth.—2-4 fms.

Specimens examined.—The type and paratype, from 1 station.

¹² *cocosi*, of Cocos Island, the only place where it has been taken.

***Encope galapagensis* A. H. Clark**

Plate 57, Figs. 50-51

Encope micropora galapagensis A. H. Clark, 1946, p. 7.

One of the most interesting results of the study of the large number of *Encopes* in the *Velero* collection was the discovery that the Galapagos form is easily recognizable as a distinct species. The character upon which the subspecies was based is not perfectly constant, for while the test is as a rule equally high both in front of and behind the middle, there is individual diversity which results in many specimens being slightly highest anterior to the middle. Very rarely a specimen is highest posteriorly. The most obvious character is the color, commonly an antique or brussels brown above with the margins of the lunules as well as of the test itself dusky purple. The lower side is a dark purple drab, sometimes quite purple, sometimes quite drab. The contrast between the upper and lower surfaces is usually marked. About 10 per cent of the specimens tend to be either grayish with a purple cast or even a rather evident purple. Such specimens show little evidence of the antique brown of normal specimens. The lunules are commonly elongated and relatively narrow, from 2 to 4 times as long as wide, but the anterior lunules are frequently small and more nearly circular. The unpaired lunule is longest and its anterior end is commonly between the tips of the posterior petals, but in some individuals a line between those tips would be entirely anterior to the unpaired lunule. Commonly the test is nearly circular but it is usually a little wider than long when full grown. The margin between the posterior petals is often nearly or quite straight but is commonly more or less convex.

The smallest specimen at hand is 10 mm in diameter with only the unpaired lunule evident. At 12-15 mm the posterior paired lunules appear as notches in ambulacra 1 and 5, but the notches indicative of the 3 anterior lunules are not evident until the young *Encope* is about 25 mm across. These young are very pale gray brown but at 3 mm the color is more brown and margin of the test is purple as in adults but not markedly so. The largest individuals exceed 130 mm in diameter, the length and breadth about equal or the width greater. At Tagus Cove, Albemarle Island, fine specimens were secured, 152 x 151 mm, and at Academy Bay, Indefatigable Island, specimens 150 x 155 mm were collected.

Distribution.—This fine *Encope* was taken only at the Galapagos Islands, from North and South Seymour Islands and Indefatigable, Albemarle, Charles, Hood, and Chatham Islands.

Type.—U.S.N.M. No. E. 6817.

Type locality.—Chatham Island, Galapagos.

Depth.—2-73 fms.

Specimens examined.—120 specimens from 22 stations.

***Encope irregularis*¹³**, new species

Plate 58, Figs. 52-53

Test stout and more or less irregular in shape. Of all the specimens at hand, only one, a relatively young one, is symmetrical. The one selected for holotype is here used as basis of description but no other specimen is like it in all details. Length 112 mm, width 116 mm, height 13 mm. Apex of test only 25 mm back of anterior margin, from which point the test slopes gradually to posterior lunule and thence rapidly to margin. Unpaired petal and anterior pair of about equal length, 35 mm and width 18-20 mm; poriferous zones, 4 mm across with some 20 very small tubercles in each series; interporiferous area 10 mm wide with very fine tuberculation; tips of petal open, only 4 mm from anterior lunule, which is only about 5 mm from margin and is 9 x 4 mm in size. Anterior paired lunules about 40 mm from anterior end of test; each is about 8 mm long by 3 mm wide; the right hand one is closed by about 7 mm of test but the left hand one has never closed, though the lower margin has bent forward as though to do its part. Posterior petals somewhat longer than anterior but essentially similar. Interambulacral lunule small, only 8 mm long by 2.5 mm wide; its posterior end is 15 mm from rear end of test and its anterior end is well within (3 or 4 mm) the line joining the tips of the posterior petals. Posterior lunules short and narrow, 10 x 2 mm, only about 7 mm from test margin. Lower surface flat or barely concave, the pattern formed by the ambulacra unusually distinct and striking. Spines of abactinal surface relatively short and crowded, the tips swollen and flat for the most part but around the lunules long, flat and pointed or truncate. Color of abactinal surface very dark, approximately fuscous or fuscous black of Ridgway; the marginal fringe of short spines, the tips of the spines around the lunules and the whole lower surface are brown of some shade, usually dark and often with a purple cast. There is considerable diversity in the shades of color, so that no two individuals are exactly alike. In one large specimen there is a distinct hint of deep green, while in several dark violet is indicated. In general one may say the color is dark and dull.

Besides the holotype there are 21 specimens of this *Encope*, but 4 of these are so small (less than 25 mm) their identity is based wholly on the fact that they are from the coast of Costa Rica. The remaining 17 are remarkable for their asymmetry. The smallest, 85 mm in length, shows no

¹³ *irregularis*=lacking regularity in form or character, in reference to the fact that nearly all the specimens are imperfectly formed at least in some detail.

striking defect but all of the rest are surprisingly different from each other. The least asymmetrical has a noticeable concave margin adjoining the right posterior lunule; the holotype has the left anterior lunule still unclosed; in another the lunules, especially the anterior one, are small; in several two or more lunules are unclosed; and finally a specimen 135 x 130 mm, is the most distorted of all, having no two interradian margins alike, only the anterior and the interambulacral lunules closed, and the whole left margin irregularly distorted.

Distribution.—The holotype and 13 paratypes are from Octavia Bay, Colombia, in 2 fms. Two small adults (about 115 mm long) are from Bahia Honda, Panama, one from shore, the other in 15-20 fms, and a similar but smaller specimen is from the Secas Islands, in 3 fms. The very irregular abnormal adult described above and 3 very young individuals are from Salinas Bay, Costa Rica, in 2 fms. The other very small specimen is from Cocos Bay, south of Port Culebra, Costa Rica, in 2 fms. Apparently this is a southern species, reaching a northern limit in Costa Rica.

Type.—Holotype AHF no. 53, 13 paratypes.

Type locality.—Station 434-35, Octavia Bay, Colombia, 2 fms, January 28, 1935.

Distribution.—Colombia to Costa Rica.

Depth.—2-20 fms.

Specimens examined.—The type, paratypes and 8 specimens from 6 stations.

***Encope ecuadorensis*¹⁴, new species**

Plate 59, Figs. 54-55

Test rather stout, 139 mm long, 146 mm wide and 15 mm high; greatest thickness just anterior to the paired petals, when it decreases slowly until near the posterior lunules and then more rapidly to margin. Unpaired petal 40 mm long and 15 mm wide, elongated elliptical; poriferous zones narrow, less than one-fourth of petal width, the pore-pairs rather crowded, the ridges between with a close series of 12-16 tubercles; closed tip of petal (which is damaged in the holotype) is about 10 mm from the lunule, which is 12 mm long by 4 mm wide, and some 9 mm from the margin. Anterior paired petals shorter and wider than the unpaired one, the form being somewhat oval rather than elliptical; they point to the anterior lunules which are 13 x 5 mm, and 10 mm from margin. Posterior

¹⁴ *ecuadorensis*, in reference to the country where this is the local *Encope*.

petals a bit longer but not equal to the unpaired one, the lunules 18 x 5 mm and 10 mm from margin. Interambulacral lunule relatively small, about equal to one of the anterior pair; its posterior end about 10 mm from margin. Lower surface of test flat and not peculiar. Spines of abactinal surface very numerous, slender with abruptly bulbous tips, lying inclined towards horizontal, forming a fairly close coat; on the lower side the spines are relatively long but lie nearly horizontal; they may be blunt or pointed but are not notably enlarged at tip. Color of upper surface Saccardo's umber of Ridgway's Standard, but warm sepia and cinnamon brown on oral surface.

In addition to the holotype, there are but two other smaller adults and a bare test. This test is 130 mm long, 125 mm wide and 13 mm high; aside from its elongated form it is peculiar in having the anterior petal more elongated than in the type and relatively narrower. One of the other specimens, 120 mm long by 122 mm wide, is notable for its very dark color, Chaetura drab above, and cinnamon drab orally on the interambulacra, more drab on the ambulacral areas. The test itself is light olive gray. The other small adult is about 107 mm each way and the color is intermediate between the other two adults, a dull drab above, more cinnamon below. Although resembling *fragilis* in some ways, the character of the more solid test and the narrow poriferous zones of the anterior petal serve to distinguish this southern form.

Distribution.—This *Encope* is the tropical continental species, quite different from the Galapagos species and readily distinguished from the Panamic or Mexican forms. In addition to the 4 adults, there are 92 young *Encopes*, 5-30 mm in diameter which are too young for positive identification but are here considered as *ecuadorensis* on geographical grounds. The material was all taken at 5 stations on the Ecuadorean coast between Santa Elena Bay, Lat. 2° 10' 36" S, and San Francisco Bay, Lat. 0° 38' 40" N, in 2-12 fms.

Type.—Holotype, AHF no. 54, 2 paratypes.

Type locality.—Station 205-34, Santa Elena Bay, off La Libertad, Ecuador, 8-10 fms, February 8, 1934.

Distribution.—Ecuador.

Depth.—2-12 fms.

Specimens examined.—The type, paratypes and 93 specimens, from 6 stations.

***Encope fragilis*¹⁵**, new species

Plate 60, Figs. 56-57

Test rather fragile, 124 mm long, 130 mm wide and 10 mm high; greatest thickness just a little back of tip of unpaired petal which is 30 mm long and 14 mm wide; poriferous zones wide, the two equal in width to the median area; pore-pairs crowded, the narrow ridges between them covered by a single series of 20-24 minute tubercles; closed tip of petal 5 or 6 mm from anterior lunule which is 8 mm long and about 1.5 mm wide; its tip 8 mm from disk margin. Anterior paired petals about 26 mm long and 13 mm wide; they point directly to anterior lunules which are about 10 mm from their tip and measure 12 mm long by 2 (or less) wide. Posterior petals almost duplicates in size and form of the unpaired one. Posterior lunules about 15 mm long, 2.5-4 mm wide. Interambulacral lunule very large, 20 mm long by 8 mm wide, only about 8 mm from margin. Lower surface of test perfectly flat but not peculiar. Spines of abactinal surface very numerous, slender with abruptly bulbous tips lying almost horizontal, forming a delicate smooth coat; spines around lunules long and pointed, those of lower surface slender, pointed or blunt or even a bit widened at tip. Light brownish olive above, brightest on the petaloid area and on the lunule margins, darkest at disk margin; faintly outlining many plates are dark, Andover green lines, forming an indefinite but more or less evident pattern; lower surface a tawny olive.

In addition to the symmetrical and handsome holotype there are 5 other *Encopes* clearly belonging to this striking species. The smallest measures 80 x 80 mm with a thickness of 8 mm; the anterior and left posterior lunules are not completely closed in; a less symmetrical specimen is 90 x 88 mm and has both the right hand lunules open; a very symmetrical specimen, 90 x 92 mm has all the lunules fully closed; a very unsymmetrical and irregular adult is approximately 135 mm long and 125 mm wide; no lunule is closed in save the anterior which is imperfectly shut in. The largest individual is 154 mm long, 152 mm wide and 11 mm thick (35-40 mm back of the anterior margin); the dull greenish lines are present but much less evident than in the holotype. Of the smaller specimens only one gives any indication of them.

Distribution.—Most of the material referable to this very striking species was taken in or near Petatlan Bay, Mexico, at 5 stations. The holotype is from Station 764-38, near White Friars Rocks, Mexico, in 15-20 fms; the largest specimen and the very irregular adult mentioned above are from Station 963-39, nearby but in slightly deeper water (20-25

¹⁵ *fragilis*=easily broken, in reference to its relatively delicate structure.

fms), and the 3 young individuals also mentioned are from Station 265-34 in Petatlan Bay, close by in 5-10 fms. In addition to these clearly identifiable specimens there are 146 small *Encopes*, 4-15 mm across, which are presumably young individuals of this fine species. Fifty-eight of these are from Station 764-38 (Type station). The others are from Station 264-34, south of White Friars, in 25 fms; Station 265-34, Petatlan Bay, 5-10 fms; Station 267-34, west of Morro de Petatlan, 25 fms and Station 965-39, Tenacatita Bay, 8-15 fms.

Type.—Holotype, AHF no. 55, 5 paratypes.

Type locality.—Station 764-38, North of White Friars, Mexico, 15-20 fms, January 8, 1939.

Distribution.—Petatlan Bay to Tenacatita Bay, Mexico.

Depth.—5-25 fms.

Specimens examined.—The type, paratypes and 146 juvenile specimens from 6 stations.

***Encope insularis*¹⁶, new species**

Plate 61, Figs. 58-59

Test large and flat, moderately thin at the margins, conspicuously flat and thin in young specimens (under 100 mm in diameter). Length 135 mm, width 133 mm, height 14 mm; greatest thickness on a line connecting the anterior lunules, whence test slopes evenly to the anterior margin and somewhat more gradually to the posterior margin. Unpaired petal about 30 mm long and 12 mm wide becoming somewhat pointed at tip but not closed; the poriferous zones are narrow (3 mm) with the ridges bearing about 10 tubercles; the interporiferous area is 6 mm wide, its tip about 11 mm from the anterior lunule which is 9 mm long and nearly 4 mm wide, located 8 or 9 mm from test margin. Anterior paired petals rather far back, a little shorter and wider than the unpaired one. Lunules of these petals very similar in size and form to that of the anterior area. Posterior petals longer than the others, about 35 mm in length and 15 mm wide, their lunules long and narrow, 20 mm by 5 mm only 8 mm from margin. In all specimens except the holotype and the next largest, these lunules remain open distally. Interambulacral lunule long and narrow, about 20 by 4 mm, nearly 20 mm from margin, its anterior end 8 mm in front of the paired lunules. Posterior margin of test nearly straight in the type but less definitely so in other specimens. Lower surface of test flat and not peculiar. Spines of abactinal surface very numerous, slender with more

¹⁶ *insularis*, of an island, in reference to its occurrence at Socorro and Clarion Islands.

or less markedly bulbous tips, lying inclined towards horizontal and forming a fairly even coat; in other specimens the bulbous tips are less uniformly evident, and the coat is not so smooth. Color mummy brown, the lower surface a brighter shade.

Besides the holotype, there are 4 other adults (100 to 120 mm in greatest diameter) which undoubtedly represent this rather fragile species. The largest closely resembles the type but is a somewhat brighter brown. The other 3 are nearly black, the smallest in particular is very dark above and light purplish gray on the oral side. A specimen 75 mm in diameter is a deep brown while a test 53 mm across is more nearly black. There are 2 bleached fragments and 4 very young individuals which are labeled as from Clarion or Socorro Islands.

Distribution.—The holotype, which is the largest specimen, was taken in Braithwaite Bay, Socorro Island, in 14-18 fms, in January, 1934, and another adult and 8 young individuals were collected at the same time and place. Five months later, 2 small adults, 2 very young specimens and a water worn fragment of an adult were taken at or near the same spot. Five years later one fine adult and 2 very young individuals were taken at Sulphur Bay, Clarion Island, in 25-45 fms. Apparently the species is confined to the vicinity of those two islands.

Type.—Holotype, AHF no. 56, 4 paratypes.

Type locality.—Station 129-34, Braithwaite Bay, Socorro Island, Mexico, 14-18 fms, January 3, 1934.

Distribution.—Socorro and Clarion Islands, Mexico.

Depth.—14-45 fms.

Specimens examined.—The type, paratypes and 13 specimens, from 5 stations.

***Mellita longifissa* Michelin**

Plate 62, Fig. 60

Mellita longifissa Michelin, 1858, p. 360, pl. 8, fig. 1.

This striking and easily recognized sand-dollar seems to be either very rare or very hard to collect for in all of the many years collecting by the *Velero*, it has been met with but once, when 2 apparently dead tests were taken at San Juanico Bay, well up on the western coast of Lower California. They were evidently picked up on the beach as the label reads simply "shore." One is completely bare of spines and is a trifle water worn. The other, which is slightly the larger, has rather more than half the upper surface still fairly well covered with the short, curved, capitate, white spines. As the epidermis of the test is apparently black or blackish, the resulting effect is a "pepper-and-salt" gray. Apparently this was at least

approximately the color in life. This specimen is 70 mm long, 75 mm wide and 9 mm high at the test apex, which is about 30 mm from anterior margin. The unpaired lunule is 22 mm long and 1.5 mm wide. The rarity of this well-marked species, more apparent perhaps than real, is probably due to an unusually subterranean habit which defies ordinary trawling and dredging.

Distribution.—Gulf of California to Panama.

Type.—Paris Museum?

Type locality.—"Habite.-Localite inconnue.-Collection Michelin."

Depth.—Shore to 30 fms.

Specimens examined.—2 specimens from 1 station.

Family **Cassidulidae**
Cassidulus pacificus (A. Agassiz)
Plate 62, Fig. 61

Pygorhynchus pacificus A. Agassiz, 1863, p. 27.

Cassidulus pacificus Grant and Hertlein, 1938, p. 108, pl. 13, fig. 6; pl. 29, figs. 4, 5; pl. 30, fig. 6.

Mortensen, 1948, Monograph of the Echinoidea, IVi, p. 210, pl. 2, figs. 1, 2, 11-13, 19; pl. 11, figs. 2, 11-13.¹⁷

This interesting Cassiduloid is represented by 19 specimens and fragments of another. The fragments are the ventral surface of a large individual about 50 mm long by 40 mm wide, and half a dozen pieces of the upper part of the test. The chief interest in these pieces is the color, for they have preserved the color of the living animal to a remarkable degree. The ground color is cream color becoming quite yellow along the sides and on the margins of the lower surface. This surface is quite white and unspotted but the upper surface is covered with irregular blotches of Andover green. Around the periproct, more particularly below it, is an evident patch of vinaceous drab. With these fragments, a specimen 20 x 17 x 10 mm was taken which is undamaged; it is nearly white with evidence of cream color and with irregular rather numerous small blotches of purple. The other 18 specimens show considerable diversity; 5 specimens are quite brown, the largest one conspicuously blotched at the anterior end, dorsally with a darker shade; several half grown individuals are nearly white, with faint indications of small dusky blotches; some small specimens are light gray without spots. These small individuals are about 8 mm long.

¹⁷ This work unknown to Clark, being published only half a year after his death.
—Th. M.

Distribution.—The *Velero* found no Cassiduloids along the mainland coast. All of the 20 specimens were taken at islands, 9 at Socorro, 9 at Clarion, and one, with the adult fragments was dredged in 48-73 fms near Barrington Island in the Galapagos Islands. The Socorro specimens were found in 4-10 fms near Cape Rule and in deeper water (10-30 fms) in Braithwaite Bay. The Clarion material was taken off the north side of the island in 30-56 fms or off Sulphur Bay in 25-26 fms. Other records show the distribution to include the Gulf of California to Panama.

Type.—M.C.Z. no. 2719 (Cotype).

Type locality.—Acapulco, Mexico.

Depth.—4-73 fms.

Specimens examined.—20 specimens from 7 stations.

Family **Hemiasteridae**
Agassizia scrobiculata Valenciennes
Plate 63, Figs. 62-63

Agassizia scrobiculata Valenciennes, 1846, pl. 1, figs. 2-2f.

Although this Spatangoid is reported from various stations between Mazatlan, Mexico and Capon, Peru, the *Velero* met with it very rarely. A bare test, 16 x 13 x 10 mm was found on shore at Willards Island, Gulf of California, far north of Mazatlan, and a large bare test (21 x 19 x 16 mm) was picked up on shore at Cartago Bay, Albemarle Island, Galapagos Islands. One of the prizes of the *Velero's* visit to the Galapagos in 1938 is a remarkably fine test of this Spatangoid presented to Captain Hancock by Mr. Osorio of Ritter's Landing, Charles Island. It was picked up along shore but is neither bleached nor damaged in any way, although the spine-coat is entirely lacking. It measures 55 mm in length, 50 mm in breadth, and 40 mm in height. The color is a dull light brown, the 4 genital and 5 ocular pores are easily seen and the fascicles are notably distinct. This is by far the largest specimen yet recorded. Besides these bare tests, the *Velero* dredged one living specimen, a very unusual capture. It is 16 x 14 x 12 mm with the surprisingly long white spines, 2 to 3 mm. The test is white but the dried muscles at the bases of the spines are yellow brown, so the whole effect is very pale brown. This interesting capture was made in the Gulf of California, between Angel de la Guardia and Mejia Islands, in 6-11 fms.

Distribution.—Gulf of California to Peru; Galapagos Islands.

Type.—Paris Museum?

Type locality.—Unknown.

Depth.—Shore to 11 fms.

Specimens examined.—4 specimens from 4 stations.

Brisaster townsendi (A. Agassiz)

Plate 64, Fig. 64

Schizaster townsendi A. Agassiz, 1898, p. 82.*Schizaster (Brisaster) townsendi* Mortensen, 1907, pt. 2, p. 123.*Brisaster townsendi* H. L. Clark, 1917, p. 179, pl. 155, figs. 4, 6, 8.

A common Spatangoid of the Eastern Pacific between southern Alaska and the Galapagos Islands, this species was taken by the *Velero* at 14 stations. The largest of the 120 specimens is badly damaged but measures 60 mm in width and must have been about 70 mm long and some 30 mm high. The smallest is 7 x 5.5 mm. All are some shade of brown, ranging from a very light shade, with fascicles conspicuously darker (Station 1163-40, 215-225 fms) to a very dark brown, the fascioles more or less conspicuous (Station 1497-42, 60-74 fms).

The specimens from Station 1133-40, off Redondo Beach, California, in 49-172 fms are remarkable for having the lateroanal fasciole developed as a conspicuous band more or less closely surrounding the anus, not in any sense lateral. At several stations both *Brisaster* and *Brissopsis* occur and it seems probable that some of the puzzling specimens are hybrids. In his full description of this *Brisaster*, Agassiz (1904) refers to the shape of the young when 10 mm in diameter. Some of the *Velero* specimens are smaller than that and have a very striking pentagonal form. These young pentagonal individuals have the sides of the pentagon measuring 5 or 6 mm. The peripetalous fasciole follows the margin of the pentagon on the upper side. Ventrally each interambulacrum is a convex bulge, the posterior (subanal) one somewhat the largest. The mouth is but little anterior to the center, and there is no definite sternum.

Distribution.—The *Velero* took *Brisaster* at stations ranging from Oregon (Station 1497-42, Lat. 44° 49' 10" N) to southern California (Station 1223-41, Lat. 33°, 27' 10" N), at depths of 20-250 fms, but the bulk of the specimens are from the vicinity of the Channel Islands in depths of more than a hundred fathoms. The greatest depth was in San Pedro Channel at 225-250 fms. Off Redondo Beach specimens were taken at 49-172 fms and off Santa Cruz Island in 64-134 fms. The absence of *Brisaster* from stations further south is no doubt due to the little dredging the *Velero* did at greater depths than 150 fms, for the *Albatross* material on which the species is based was collected at depths of 146-995 fms at stations from the Gulf of California to Panama. Other records extend the range north to southeastern Alaska.

Type.—M.C.Z. no. 2961 (Cotype).

Type locality.—Gulf of Panama to Guaymas, Mexico.

Depth.—20-995 fms.

Specimens examined.—120 specimens from 14 stations.

***Moira clotho*¹⁸ (Michelin)**

Plate 64, Fig. 65

Moera clotho Michelin, 1885, p. 247.*Moira clotho* A. Agassiz, 1872a, p. 147.

H. L. Clark, 1917, p. 196, pl. 156, figs. 5-7.

This odd, highly specialized Spatangoid is easily recognized by the deeply sunken, narrow, paired petals and even more deeply sunken anterior petal which presumably serves as a brood pouch for the young. The genus includes several species and ranges from the southeastern coast of the United States and the western coast of tropical America to Japan and Australia, to Suez, and Zanzibar, but apparently does not occur in European seas or on the west coast of Africa. The *Velero* met with it at 4 widely separated stations. There are 35 specimens altogether but more than half are very small, 5-10 mm long, and none are very large. These small ones are chiefly from Ecuador in 1 or 2 fms. The finest specimens are from the upper end of the Gulf of California, near Consag Rock, on a bottom of brown mud in 21 fms. The largest are about 26 mm long, by 22 mm wide by 18 mm high. They are almost pure white in color with the lateroanal fasciole yellow.

Distribution.—Gulf of California to Ecuador.*Type*.—Paris Museum?*Type locality*.—Mazatlan, Mexico.*Depth*.—1-21 fms.*Specimens examined*.—35 specimens from 4 stations.**Family Spatangidae*****Brissopsis pacifica* (A. Agassiz)**

Plate 65, Figs. 66-67

Toxobrissus pacificus A. Agassiz, 1898, p. 83.*Brissopsis pacifica* Mortensen, 1907, p. 168.

H. L. Clark, 1917, p. 203, pl. 155, fig. 1.

This is apparently the commonest Spatangoid in the Eastern Pacific. The *Velero* took 674 specimens at 65 stations. They range in size from very young (6 x 5 mm) to big adults (57 x 47 x 31 mm), but the very great majority are less than 35 mm long. As both *Brissopsis pacifica* and *Brisaster townsendi* were taken at 6 stations, it is not surprising that hybrids occur apparently with considerable frequency. While the two species are alike in dull coloration, *pacifica* tends to lighter shades and the fascioles are more conspicuous. There is some evidence that muddy or even foul

¹⁸ In Grant and Hertlein, 1938, the specific name is consistently misspelled "*clothro*." H.L.C.

bottoms affect the coloration and appearance of the specimens but the data are not adequate to warrant positive statements. The evidence of hybridization with *Brisaster* has been presented under the discussion of *Brisaster townsendi*.

Distribution.—The fact that *Brissopsis* was taken at 65 stations is evidence of its general distribution, but an analysis of the data shows that nearly all the material is from moderately deep water off the coast of California, particularly in the vicinity of the Channel Islands. Specimens were secured near Clarion Island, but the most notable extension of the range is the taking of 2 small but indubitable specimens at Station 786-38, northeast of Indefatigable Island in the Galapagos Islands, in 392 fms.

Type.—M.C.Z. no. 3063 (Cotype).

Type locality.—*Albatross* Station 3355, off Point Mala, Panama, 182 fms.

Depth.—5-39 fms.

Specimens examined.—674 specimens from 65 stations.

***Plagiobrissus pacificus* H. L. Clark**

Plate 66, Figs. 68-70

Plagiobrissus pacificus H. L. Clark, 1940, p. 351, pl. 2, figs. 3, 4.

The occurrence of this rather striking Spatangoid in the Gulf of California is of great interest as it was known hitherto only from the type and paratype taken on Hannibal Bank, Panama, in 35 fms. In the *Velero* collection there are 67 specimens of this interesting Spatangoid, of which 9 are large enough to be called adults, but the test is thin and fragile and 4 are more or less crushed. The smallest is 10 x 7.5 x 4.5 mm and is quite undamaged. The largest is 56 x 41 x 20 mm, thus much larger than the holotype. Several specimens have a gray tint to the test instead of brown and there is a great deal of diversity as to the degree of brownness. While the general tuberculation and the arrangement of fascioles agree well with *Metalia*, the shape of the test is quite different from the short thickset form of most of the known species of that genus, and the large tubercles in interambulacra 1 and 5 show conclusively that it is not that genus.

Distribution.—All the material of *Plagiobrissus* was taken in the Gulf of California at depths of 5 to 75 fms except 3 specimens, as follows: a single fine bare test from Station 948-39, which is in Panama Bay in 30-35 fms; a very good half-grown specimen from Station 773-38, which is off Nuez Island, Cocos Island, in 31-50 fms; and a damaged young individual, 14 mm long, whose identification is somewhat dubious, from Station 212-

34, off La Plata Island, Ecuador. Apparently this Spatangoid occurs throughout the Panamic region, but further material is necessary to establish the limits of its distribution.

Type.—M.C.Z. no. 7625.

Type locality.—Hannibal Bank, Panama, 35 fms.

Depth.—5-75 fms.

Specimens examined.—67 specimens from 19 stations.

Idiobryssus coelus H. L. Clark

Plate 67, Figs. 71-73

Idiobryssus coelus H. L. Clark, 1939, pp. 173-176, pl. 17.

The holotype of this odd little Spatangoid is the only specimen at hand. It was taken, together with a smaller paratype, in 40-70 fms, in Darwin Bay, Tower Island, Galapagos Islands, January 16, 1938. It is 12 mm long by 10 mm wide and 4 or 5 mm high. The color in life was white, but the dry specimen is more or less pale brown. The paratype is in the Museum of Comparative Zoology, Cambridge.

Distribution.—Tower Island, Galapagos Islands.

Holotype.—AHF no. 2.

Type locality.—Darwin Bay, Tower Island, Galapagos Islands.

Depth.—40-70 fms.

Specimens examined.—The type.

Brissus latecarinatus (Leske)

Plate 67, Fig. 74; Plate 68, Fig. 75

Spatangus brissus var. *latecarinatus* Leske, 1778, pp. xx, 185.

Brissus carinatus Gray, 1825, p. 431.

Brissus latecarinatus H. L. Clark, 1917, p. 219.

This widespread Indo-Pacific Spatangoid has long been known from the Panamic region but the *Velero* has not secured many specimens nor are any of those at hand even half grown. Moreover of the 21 specimens, 16 are bare tests, nearly all bleached, and the largest is only 56 x 44 x 30 mm. This is almost one-third of the size of the largest recorded specimen, now in the collection of the California Academy of Sciences, which Grant and Hertlein (1938, p. 130) describe as 166 mm long, 128 mm wide and 106 mm high. Of the *Velero* specimens having the spines on and evidently alive when taken, the largest is 39 x 32 x 32 mm (Station 1079-40). The other *Velero* specimens, alive when taken, were found at Secas Islands, Panama (Station 446-35) and at Pond Island, Gulf of California (Station 1079-40). The bleached tests at hand, were found along the east shore of Angel de la Guardia Island, March 6, 1936; at

Willards Island, in January, 1940, and at Puerto Refugio, Angel de la Guardia Island, also in January, 1940. All the specimens at hand were taken along shore.

Distribution.—Gulf of California to Panama; Indo-Pacific from Hawaii, Australia to the Red Sea and Japan.

Type.—Unknown.

Type locality.—Unknown.

Depth.—Shore.

Specimens examined.—21 specimens from 6 stations.

Meoma grandis Gray

Plate 68, Figs. 76-77

Meoma grandis Gray, 1851, p. 132.

A. Agassiz, 1873, p. 603, pl. 34, figs. 1, 2.

This big dull-colored Spatangoid appears to be common in the tropical Eastern Pacific, north of the equator, and the *Velero* collection contains some 90 specimens from 25 stations. All, however, are adults as the smallest is 80 x 72 x 39 mm. The largest is nearly twice that but is at present broken into two large bare pieces. It was in life at least 150 mm long, by 137 mm wide and 75 mm high. No other specimen is nearly so large, the biggest being 120 x 110 x 50 mm. Only 2 specimens, besides the large fragments, are bare. The color of the naked tests is a light brown gray or a deep brown with a violet cast. All of the other specimens are brown, usually very dark but the fragments from Cocos Island are definitely yellow brown. Several specimens are nearly black. On the whole, this *Meoma* must be regarded as the dullest colored, most unattractive echinoid of the west coast.

Distribution.—*Meoma* ranges from Port Utria, Colombiafi some 6 degrees north of the equator, in 15-30 fms, to the upper end of the Gulf of California (Angeles Channel, 28° 57' N). At the outlying islands, the *Velero* took good specimens in Braithwaite Bay, Socorro Island, and fragments of at least two large ones in Chatham Bay, Cocos Island. At the Galapagos Islands, the only specimen met with was the very large one, whose bare fragments were dredged in 58-60 fms, east of the south end of Albemarle Island. The bathymetric range of *Meoma* is not great, from along shore in a fathom or so to something less than 60 fms.

Type.—British Museum (No number).

Type locality.—Gray's original locality, "Australia," generally considered erroneous.

Depth.—Shore to 60 fms.

Specimens examined.—90 specimens from 25 stations.

Spatangus californicus H. L. Clark

Plate 69, Figs. 78-79

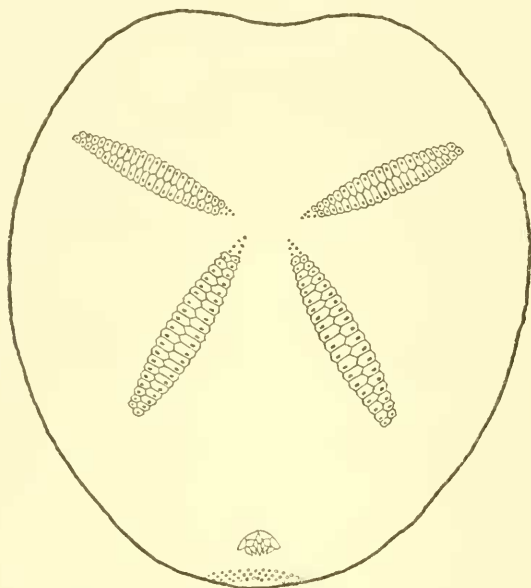
Spatangus californicus H. L. Clark, 1917, p. 235, pl. 156, figs. 1-3; pl. 157, fig. 10.

This interestingly isolated *Spatangus* is represented in the *Velero* collection by 240 specimens from 47 stations, ranging in size from 21 x 18 x 12 mm to 86 x 79 x 43 mm. The general form is ovoid, more or less flattened both above and below, but some individuals are more ellipsoidal though flattened on the oral side. Occasionally the breadth equals the length and in such individuals the height may be less than half the breadth. The color shows a considerable diversity and is difficult to describe. Theoretically the test is a rich deep purple and the spines more or less nearly white, but often the test is deep red brown or, on the other hand, a clear gray without hint of red or purple. Occasionally the test is light with dark blotches and such specimens have a very different appearance and are much more nearly handsome than the dull purple one. The spines may be cream color or yellow or orange brown but are usually quite in contrast with the test.

The development of the very young into mature individuals affords some very interesting and puzzling stages which are confusing because of the resemblance to *Palaeotropus*. The striking feature of these stages is the simple nature of the ambulacral pores which are single and not paired. In some very young individuals only the pores at the apical end of the ambulacra are clearly present and each is single. There is thus no well-marked petal, only a double series of pores at the upper end of each ambulacrum as in *Palaeotropus*. With increasing age and size the older pores elongate horizontally and become two pores united by a short groove essentially like the pore-pairs on each side of the petal in *Spatangus* and its allies. This alteration in the appearance of the petals does not take place at the same stage of development in all young, but usually occurs very soon after the assumption of the spatangoid form so that most individuals 8-10 mm long have normal petals of 2 columns of double pores. Rarely, individuals as much as 15-20 mm long, have only single pores in each side of the ambulacrum, and the absence of petals in such specimens is very puzzling and may cause them to be referred to *Palaeotropus*. (See Fig. 76.)

Distribution.—The *Velero* did not take *Spatangus* until February, 1936, when specimens were secured in 100-120 fms, south of Coronados Island in the Gulf of California. A little later specimens were dredged in 165 fms off San Francisquito Bay and in 100 fms a bit nearer the mouth

of the Gulf. It was over 2 years before further specimens were secured and these were taken off Santa Catalina Island in 50 fms. The following year *Spatangus* was found in deep water, 130-330 fms, off Santa Rosa Island. In the fall of 1939, 5 stations between Catalina Island and San Benito Island, Lower California, yielded numerous specimens. In the months between February 1940 and October 1941, especially in the summer of 1941, *Spatangus* was secured at many stations at depths of 35-



Text figure 3. *Spatangus californicus* x4.

225 fms. But nearly all the material was taken near or south of the Channel Islands and near San Benito and Cedros Islands. A few specimens were secured near the end of Lower California but none were taken further south nor near any of the outlying islands.

Type.—U.S.N.M. No. 789.

Type locality.—Albatross Station 2973, "off Southern California, 68 fms."

Depth.—35-225 fms.

Specimens examined.—240 specimens from 47 stations.

Gonimaretia laevis H. L. Clark

Plate 70, Figs. 80-81

Gonimaretia laevis H. L. Clark, 1917, p. 244, pl. 161, figs. 5-7.

This interesting Spatangoid, originally described from 3 small specimens (24-34 mm long) is well represented in the *Velero* collection by 57 specimens and the large adults are exceptionally handsome for a Spatangoid. The largest at hand is 42 x 36 x 18 mm, about a third larger than the holotype; the smallest, not quite 10 mm long, well shows the characteristic features of both genus and species. The color of the largest specimens is a light fawn brown but many of the smaller ones are quite a dark brown. The primary spines are not conspicuous but are very slender and quite appressed. The coat of secondary spines, in the best specimens, is very dense and has a silky appearance and feeling. The large pedicels near the mouth are a deep brown (almost black in dry specimens). Although lacking the diversity of color and the numerous long primaries of *Lovenia*, this Spatangoid rivals that notable genus in the general attractiveness of its appearance.

Distribution.—Although taken at 21 stations, this very striking "sea-mouse" (if it may be called by the popular name long ago given to *Lovenia*) was found chiefly among the Channel Islands, California, and up in the Gulf at least to Angel de la Guardia Island. A single specimen was taken at the San Benito Islands, Mexico. One lot is labeled 814-38, a station near Hood Island, Galapagos Islands, but in the absence of other specimens from south of the Gulf, this label must be regarded with suspicion. There is no doubt of the specimens being young *Gonimaretia* for they closely resemble others of the same size from the Gulf of California. While occasionally taken in 3-5 fms, most specimens were dredged in water of moderate depths, 20-165 fms.

Type.—U.S.N.M. No. 805.

Type locality.—*Albatross* Station 2911, south of San Clemente Island, California.

Depth.—3-165 fms.

Specimens examined.—57 specimens from 21 stations.

Lovenia cordiformis A. Agassiz

Plate 71, Figs. 82-83

Lovenia cordiformis A. Agassiz, 1872, p. 57.

H. L. Clark, 1917, p. 254, pl. 161, figs. 8-12.

Grant and Hertlein, 1938, p. 136, pl. 13, figs. 1, 2.

There can be little question that this relatively common Spatangoid is one of the handsomest species of the warm Eastern Pacific. It is well represented in the *Velero* collection by 100 specimens from 44 stations, but

owing to the relatively delicate test most of these, unless very small, were more or less damaged when taken. The very long primary spines are exceedingly slender and fragile and are commonly broken off to a considerable extent, and the test itself is more often broken than not. The largest specimen in the collection is from the Galapagos Islands and measures 75 x 51 x 20 mm. The anterior left corner and most of the large primaries are gone. Another very large specimen is 55 mm across but it is badly damaged at the posterior end so its living length cannot be determined. Many of the specimens are less than 10 mm in length, some less than 5 mm, and these small ones are easily confused with other young Spatangoids but if the condition of the specimen permits the internal fasciole to be seen, there can be no confusion of *Lovenia* with other genera.

The color of these striking Spatangoids is diverse, ranging from a light gray brown with the long primary spines pure white to a deep yellowish brown or a gray brown with the primaries not essentially different. The gray brown shades into lavender and purple, with the long spines conspicuously banded. The handsomest specimens are definitely light purple, fading into light brown or dirty white orally. The long spines on the sides and orally are unicolor, lavender or very pale brown, but dorsally they are prettily banded with light brown, pale orange or dirty white, and lavender or purple. The long spines of ambulacrum 3 are nearly white with widely separated very narrow bands of dark purple. Bare tests are a light dingy lavender or yellow brown, if not bleached, and the sunken primary tubercles, large oddly shaped "petals" and conspicuous inner fasciole make them unusually interesting curios.

Distribution.—*Lovenia* is a striking feature of shore and shallow water collecting at Newport and Corona del Mar. Further north it ranges to San Pedro and the Channel Islands, where it has been taken in 17-75 fms. The northern limit of its range is apparently just above 34°. It is fairly common in the Gulf of California, as far north as 29° 33', in water 2-75 fms deep. Rather common on the west coast of Mexico, it extends its range to the Secas and Jicarita Islands, Panama, in 12-30 fms. The *Velero* took it twice at Braithwaite Bay, Socorro Island, twice at Cocos Island and twice in the Galapagos Islands, at Chatham and Albemarle Islands in 4 and 30 fms. It seems a little strange that more specimens were not secured at the Galapagos Islands, for so conspicuous a shallow water sea-urchin is not easily overlooked.

Type.—M.C.Z. no. 3188 (Cotype).

Type locality.—"San Diego, Guaymas."

Depth.—Shore to 75 fms.

Specimens examined.—100 specimens from 44 stations.

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